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A track-recording coach for use at high speeds

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I. — INTRODUCTORY.

We have given previously (1) a description and the method of use of apparatus for *measuring forces* during an investigation into the behaviour of vehicles on the track. In that article repeated reference was made, especially in the discussion of the results obtained, to the condition of the track on which the stock travelled.

The riding of stock cannot, in fact, be considered separately from the condition of the track. With a few rare exceptions, the smallest peculiarity disturbing the course of a moving vehicle can be identified as due to some characteristic of the vehicle, acting in conjunction with some idiosyncracy of the track.

As the outcome of many years of research on the subject of comfort and steadiness, apparatus has been evolved for obtaining a record of the *condition of the track*, which may then be read in conjunction with the results afforded by the apparatus installed in the vehicles for the measurement of the forces set up.

Since railways began there have been appliances for ascertaining, point by point, the condition of the permanent way. It is by such means that day-to-day maintenance of the track is carried on. But such methods break down when it is desired to know the condition of tens or even hundreds of kilometres of track, before and after every trial.

That is why the Orléans Company had, since 1931, developed apparatus which, installed in a special vehicle, enabled certain features of the track to be recorded — in relation to some fixed system of reference — while travelling at high speed (2). A preliminary effort in this direction was described in the January number of the *Revue Générale* for 1933.

The early apparatus was constructed as the outcome of some investigations into the behaviour of short wheel-based vehicles at high speed; it enabled the gauge of the track and its degree of

(1) *Revue Générale* for January 1st, 1938.

(2) It will be recalled that an article appearing in the *Revue Générale* for 1st September, 1937, described an apparatus which enabled a continuous record of the low and high spots of a track to be made; however, this apparatus is unable to operate effectively at speeds exceeding 30 km. (18.6 miles) an hour.

warp, or twist, to be measured and recorded.

Encouraged by the results obtained, the combined management of the Paris-Orléans—Midi decided to complete and perfect this apparatus, and build a coach specially equipped for recording, at normal train speeds on a basis of distance travelled, the maintenance condition of each rail. It is the aim of the present article to give an account of the methods adopted and a description of the apparatus employed in obtaining this information.

But first of all brief mention will be made of the parts played, in a trial, by the track-recording coach and the stress-measuring coach already described.

II. — Object of track-recording.

The necessity for knowing the true condition of the track arises from the fact that a state of perfection in permanent way is not to be expected. Even if it were attainable, a track is not an immovable object : it yields under the influence of repeated blows from rolling stock, which tend to be delivered at nearly always the same spots. We must be reconciled therefore to some degree of tolerance and the problem turns upon what is considered to be the permissible limits of track irregularities. An entirely general solution must obviously be based upon the magnitude of the reactions set up between the fixed and moving equipment, reactions which increase in value with the train speeds and axle loads.

An irregularity in the track is not necessarily a defect; it becomes so in two cases :

(1) When it causes discomfort in a vehicle traversing it.

(2) When it gives rise somewhere in the vehicle to a dangerous variation of force, lateral thrust on the track, or reduction of the vertical load on an axle or on a single wheel.

Apparatus designed to measure the lateral or vertical forces between wheels and rails, partly solve the problem, since it indicates the place on the track at which a defect exists, but only apparatus measuring and recording the condition of the track enables the true nature of the track irregularity to be accurately diagnosed.

After each trial, therefore, of a vehicle undergoing investigation, the forces recorded are examined in conjunction with those due solely to the condition of the permanent way.

The stress-measuring coach and the coach we are about to describe are thus complementary parts of one and the same test unit, and record *simultaneously* the relevant data, which is brought together after the trial.

III. — Characteristics of a railway track.

The theoretical configuration of a track, once known, can be expressed in terms of :

(1) *The vertical co-ordinates of the rails :*

(*a*) The vertical distance of the centre of one bogie wheel from the plane containing the centres of the three other wheels of the bogie (Warp).

(*b*) The angle between the centre-line of an axle and a horizontal which lies in the vertical plane passing through the axle (Cant).

(*c*) The variation in the vertical distance of the centre of a wheel from some horizontal plane of reference (Low spots).

(2) *The transverse co-ordinates of the rails :*

(*a*) The distance between two points on the inside vertical faces of the rails, situated on the same perpendicular to the centre-line of the track (Gauge).

(*b*) The horizontal distance of a point situated on the inside vertical face of a rail, from the straight line joining two other points equidistant from the first and situated on the inside vertical face of the same line of rail (Versine).

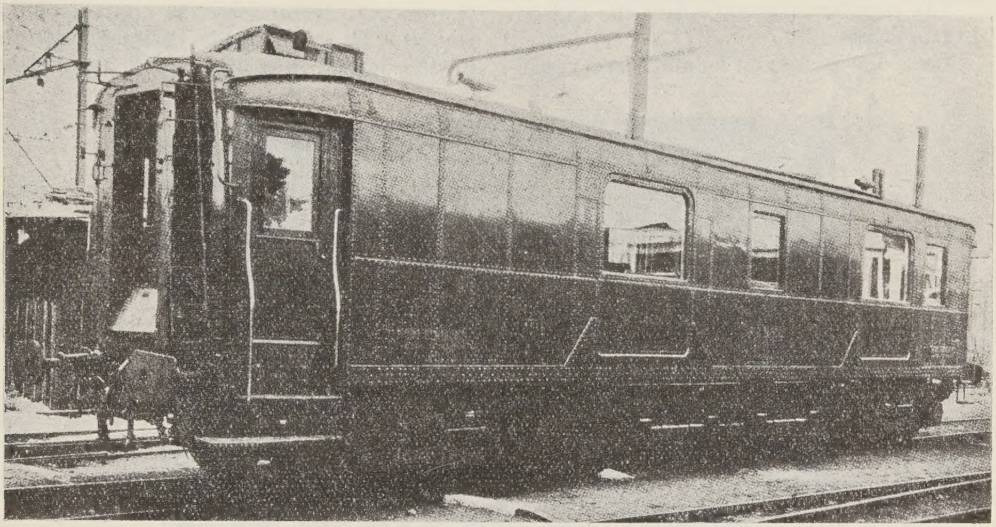

Fig. 1. — Exterior of coach for track-recording at high speed.

Later we shall see how these various quantities are measured in practice.

IV. — General description of the coach.

The track-recording coach (Fig. 1) was adapted from an all-metal bogie coach similar to that used for the stress-measuring coach (see *Revue Générale* for 1st January, 1938). In addition to the two 4-wheeled bogies of the standard type, the body also rests on a central eight-wheeled bogie fitted with free wheels. There are also a certain number of pedals and small wheels, the purpose of which we shall explain in due course.

Recording is through the medium of cables or rigid rods on to a roll of paper, unwinding proportionately to the distance travelled by the coach, in the ratio of 0.20 m. or 1 m. to the kilometre.

Besides the principal data there is also provision for recording speed, time and location.

Finally a system of adjustable electric relays enables paint to be projected on to the track at the precise points where the degree of twist or magnitude of a slack exceeds what is considered to be the limit for safe and comfortable riding.

These points are registered on a separate recorder unwinding at a slower speed (1 cm. to the kilometre).

The latter instruments have already been described in the *Revue Générale* for January, 1933. Fig. 2 is a view of the interior of the coach, showing the complete recording bench.

V. — Recording of twist.

The « twist » can be defined in the following manner : If four points on the track are taken, two on each rail, such that their projections in plan form a rectangle, then the twist is the vertical distance of one of the points from the plane containing the three other points.

It was necessary to know the twist with some accuracy, and also to eliminate, in this connection, the effect of the coning of the tyres and that of the trans-

verse action of the wheels on the track.

The problem was solved in the following manner :

The four points of contact are represented by four small wheels mounted on two small axles A and A′, carried by the special bogie in the middle of the coach, and comprising the four axles C. D. E. F. (Fig. 3).

The wheels carried by the minor axles A and A′ consist of two parts (Fig. 4); the one, A, defines, by the contact of its flange with the rail, the vertical position of the latter; the other, B, continually pressed against the edge of the rail by a spring, determines the path pursued by the flange of the small wheel, A, on the running surface of the rail. It is apparent that however many times the coach may run, the point of contact, N,

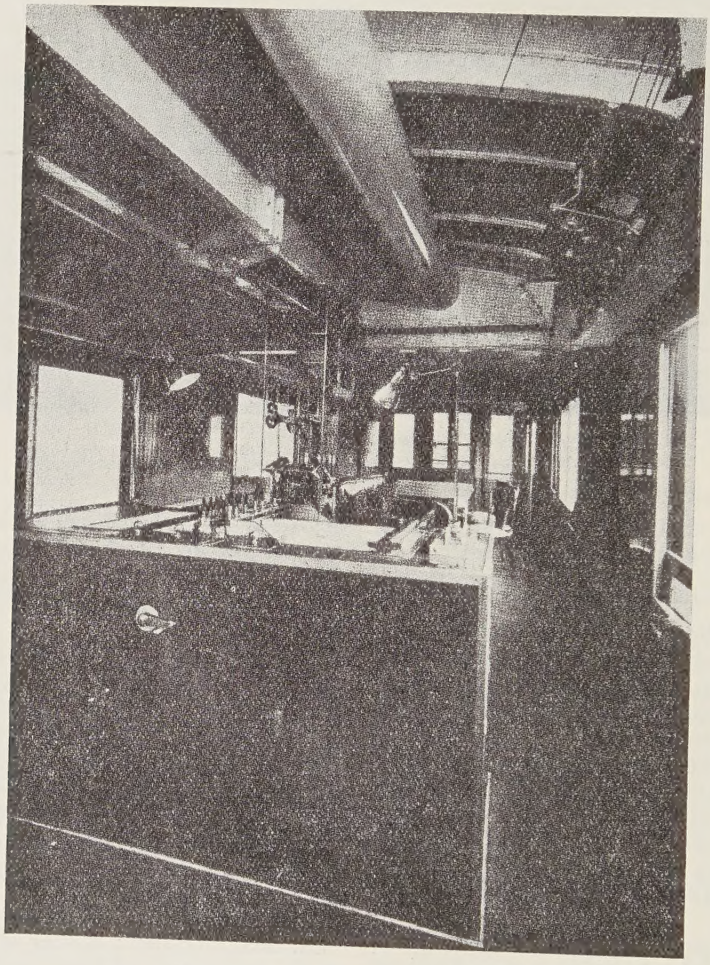

Fig. 2. — Interior of track-recording coach.

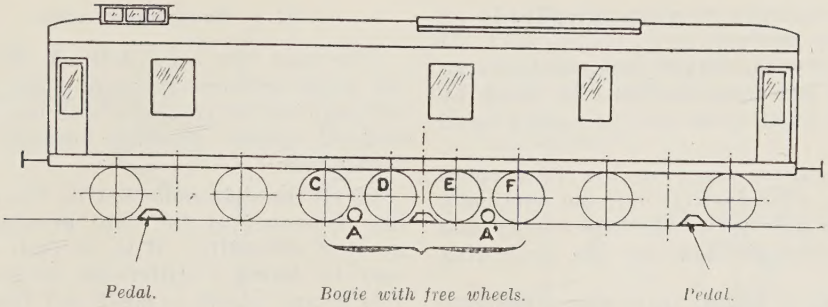

Fig. 3. — Diagram of track-recording coach.

determining the height, remains always the same.

Naturally no vertical loads can be

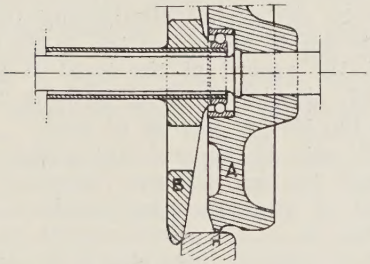

Fig. 4. — Small wheel defining the vertical distance from a rail to the coach.

transmitted to the rail by the small wheel, A. In order that the rail shall be under load vertically, the small wheels are each placed between two of the other wheels, normally loaded with the weight of the coach body. The rims and wheels are free and are mounted on axles of the construction shown in the diagram (Fig. 5).

One of the wheels is fixed to the axle whilst the other wheel is mounted on a supporting tube, AB, rotating on bronze bushes fixed to the axle, XY, and kept in position laterally by two bronze thrust blocks. The rotation of B relative to A is very slight and so far there has been no perceptible wear of the bearrings, CE and DF, nor of the thrust blocks, CG and FH.

The object of these free wheels, C. D. E. F. is to reduce the tyre wear and to avoid the transverse action resulting from axles with fixed wheels, which

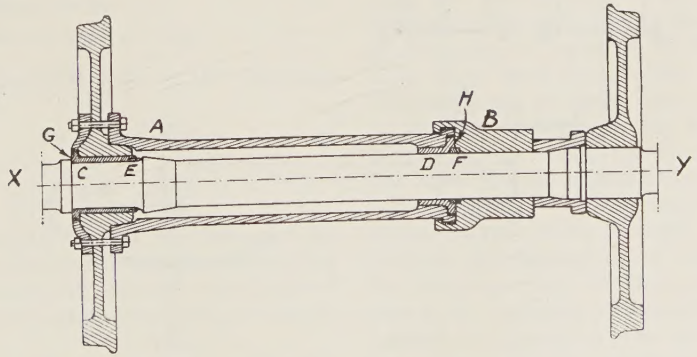

Fig. 5. — Section through axles with free wheels, of track-recording coach.

causes the rails to give, laterally, in an irregular manner.

The vertical height of a point of contact, N, is transmitted into the coach by a cable fixed to the corresponding small wheel.

The cables fixed to the four small wheels, 1-2-3-4 (Fig. 6), rise vertically into the interior of the coach-body and are interconnected in the following way :

Cables 1, and 4, from two diagonally opposite wheels pass over pulleys fixed to a rigid plane, P, itself fixed to the ceiling of the coach, and are fastened to the opposite ends of a lever, AB. In the same way, cables 2 and 3, from the two wheels situated on the other diagonal, are similarly fastened to a lever, CD.

The mid-points, E and F, of the levers AB and CD respectively, are connected by two other cables to a lever MN. The displacement of the mid-point, S, of this lever, with respect to the plane of reference, P, is proportional to the twist.

We leave it to the reader to verify that any displacement whatever of the plane P relatively to the points 1, 2, 3, 4, causes the lever MN to turn about its mid-point S, without this point undergoing any displacement relatively to the plane.

VI. — **Recording of cant.**

The cant has been defined above as the angle between the centre-line of an axle and the horizontal which lies in the vertical plane passing through this centre-line.

Of all the data collected by the coach, the recording of the cant presents the greatest difficulty. It is, in fact, necessary to detect a difference in level of 1 to 2 mm. (0.039 to 0.078 in.) from the horizontal, between two points 1.50 m. (4.92 ft.) apart (i.e. one on each rail). The angle, of the order of 1 to 2/ 1 500ths, must be recorded continuously while the vehicle is travelling at speeds up to or even exceeding 120 km/h. (75 m. p. h.).

To be certain of eliminating inertia effects due to motion of the coach body itself, the record of the twist is made use of, the latter being nothing more than the rate of change of cant.

This rate of change is integrated with respect to the distance travelled, by means of an integrating machine. In practice it is the displacement of the point S which is integrated with respect to distance (Fig. 6).

The integrator is based on the following principle :

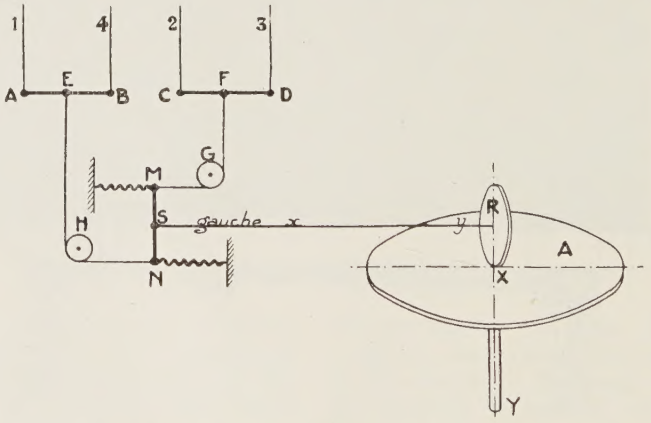

Fig. 6. — Diagram showing the principle of recording twist and cant.
Note. — Gauche = twist.

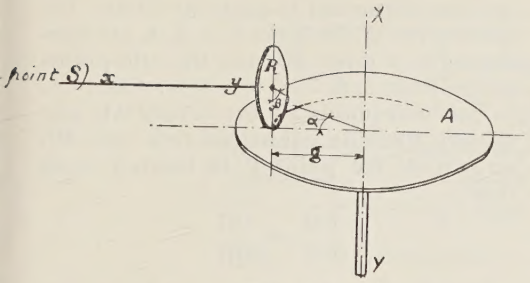

Fig. 7.
Note. — Vers le point S = to point S.

The disc A (Fig. 7) rotates about the axis XY proportionately to the distance travelled by the coach. A small wheel, R, able to rotate about the axis *xy* parallel to the plane of the disc A is engaged, by friction, with the disc. Its centre, which is free to move in the direction *xy*, reproduces exactly the displacements of the point S, so that the distance of the small wheel R from the axis XY is always equal to the twist of the track.

Let *r* denote the radius of the small wheel, *ds* the common arcs traversed by the small wheel and the disc engaged with it by friction;

α and β the angles turned through by the disc and wheel respectively;

g the distance between the plane of the small wheel and the axis XY (equal to the twist).

We can then write :

$$ds = g\alpha = rd\beta.$$

As $d\alpha$ is proportional to the distance travelled, L,

$$d\alpha = \mathrm{K}d\mathrm{L}$$

Whence :

$$\beta = \mathrm{K} \int g d\mathrm{L}.$$

This quantity is, by definition, the cant. It is thus sufficient to record the amount through which the small wheel of the integrator turns in order to obtain the cant.

In practice the integrator takes the following form (Fig. 8) : A carriage, C, is driven by the mid-point S of the lever MN. This carriage bears cylinders rotating about the axes AB, CD. These cylinders press two balls *m* and *n* on a disc

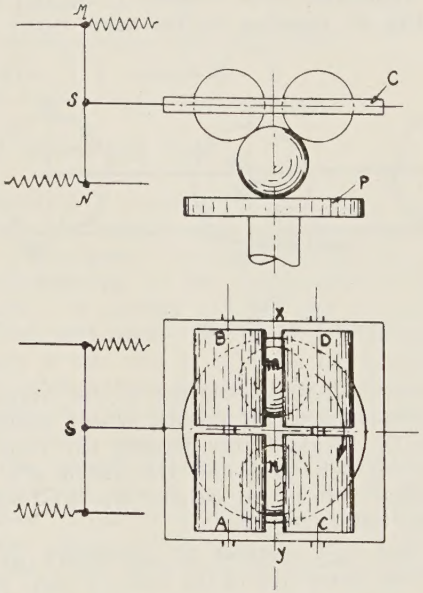

Fig. 8. — Cross section and plan view of integrator.

P, which rotates about its axis at a speed proportional to that of the rotation of an axle.

It will be readily appreciated that so long as the straight line joining the centres of the balls lies in the same plane as the axis of rotation of the disc, the balls turn upon themselves without any displacement of their centres. If there is any space between the axis of rotation of the disc and the straight line *xy*, the balls will be impelled by a force acting along the line *xy* and will be displaced along this straight line by an amount corresponding to the integral of the displacement of the point S. By means of a system of levers the balls are caused to operate a pen on the recording paper, which registers the cant at every instant.

VII. — **Recording of slacks.**

Slacks are recorded, in principle, as follows :

Consider three wheels, I, II, and III, (Fig. 9) running on the same rail. By

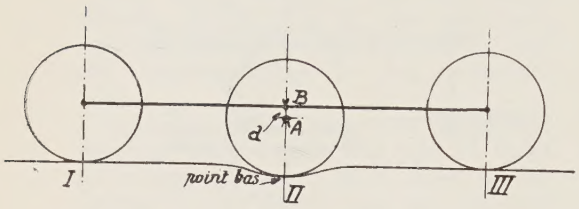

Fig. 9.

Note. — Point bas = slack.

recording the variations of the vertical distance d of the middle wheel, relative to the straight line joining the centres of the wheels I and III which are on either side of the former one we obtain the value required.

But this method is essentially unreliable since one of the outer wheels may well be in a slack itself at the moment the position of the middle wheel is being recorded.

In practice the design of the coach, which includes a central bogie with four axles, enables this inaccuracy to be appreciably reduced in the following manner :

Let 1, 2, 3, 4, 5, 6, 7, 8, be the various wheels in contact with the same rail (Fig. 10). These wheels have their centres connected in pairs by links. The mid-points of the links 1, 2, 3, 4, are connected to a lever AB, and the mid-points of the links 5, 6, 7, 8, to a lever CD.

The mid-points of the levers AB and CD are likewise connected to a link MN on which the point P is located, such that

$$\frac{PM}{PN} = \frac{QG}{QH}$$

Variations in the distance between the centre O of wheel 4 and the point P are recorded. This gives the information required.

It can be seen at once that if a certain variation in level, d, occurs in the rail, the successive passage of the wheels 1, 2, 3, 5, 6, 7, 8, will cause a displacement of the point P, equal to $\frac{d}{8}$, whilst the vertical displacement of the wheel 4 will be equal to d.

The quantity finally recorded will be within $\frac{d}{8}$ of d. In spite of having recorded only relative measurements the figure obtained is correct to within about 12 %.

It will be realised that in practice levers such as AB, CD, MN, are not employed. The entire arrangement is brought within the coach body and considerably reduced in scale (Fig. 11). The cables from the links joining the wheels 1, 2, 3, 4, 5, 6, 7, 8, pass over pulleys fixed to the coach-body and are fastened to the ends of the levers *ab*,

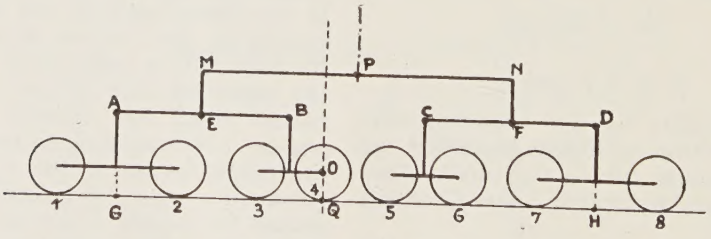

Fig. 10. — Diagram showing the principle of recording slacks.

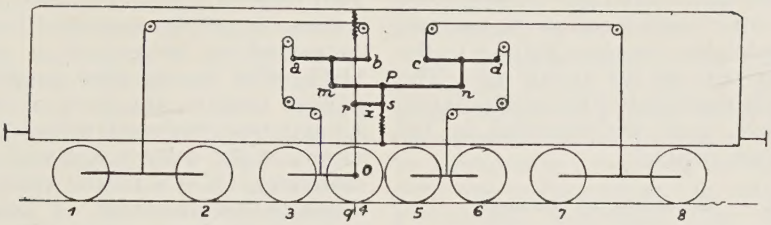

Fig. 11. — Arrangement of cables for recording slacks.

cd, mn. A point *p* is found on *mn* such that

$$\frac{pm}{pn} = \frac{PM}{PN}$$

The quantity required — the magnitude of the slack — is given by the variation in the distance of the mid-point *x*, of *rs*, relatively to the coach body. It can be easily verified that variations in the height of the coach body do not affect the recording.

VIII. — **Recording of the track gauge.**

The measurement of the gauge, like that of the versines, is performed by means of small wheels rubbing against the inside face of the rail.

These small wheels are arranged as follows :

A support consisting of two tubes is fixed, by means of their extremities, to the links of the bogie and is thus maintained at a constant height above rail level. A frame is able to slide laterally on the support in the direction of *xy*, perpendicular to the centre-line of the track. It carries at one end a small wheel, and at the other a shoe. Springs fixed at one end to a bogie link and at the other to the frame are arranged in such a way as to press the small wheel continually against the rail.

The gauge is measured as follows : Two small wheels as we have just described, situated in the same vertical plane perpendicular to the centre line of the track, each bear against the inner face of a rail.

The variations in the gauge are given by the variations in the distance apart of the two small wheels. The latter quantity is recorded as shown in Fig. 12. The small wheels are represented by 1 and 3, and points fixed on the coach body by 5 and 6.

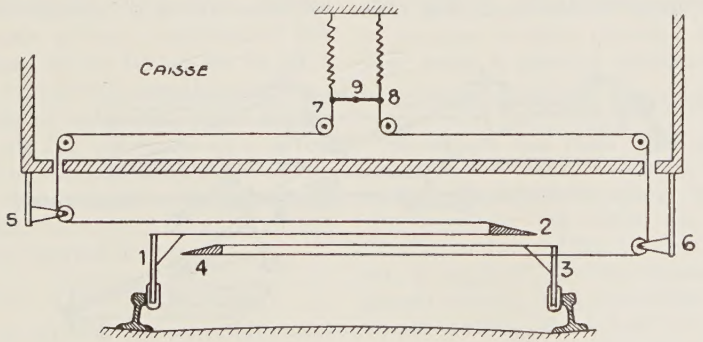

Fig. 12. — Diagram showing the principle of recording the gauge.
Note. — Caisse = coach-body.

The first cable connects point 2 with the extremity 7, of a small swing bar and the second cable connects point 4 to the other extremity of the swing bar. The vertical displacement of the mid-point, 9, of this bar, gives the variation in the gauge at any instant.

IX. — Recording of versines.

The recording of the versines, that is to say the irregularities of the alignment of the rails in the horizontal plane is done in the following manner :

Three small wheels bear continually against the same rail. The distance of the middle wheel from the straigth line joining the outermost wheels is measured, and the versine of that portion of track contained between the two latter wheels, is thus obtained.

As in the case of recording slacks it would have been idle to think of reproducing the straight line joining the outermost feelers in the shape of a girder : the inertia and vibration of such a girder would have falsified the results at high speed.

The problem was solved in the same way as that of the slacks, by bringing near the recording bench, and on a reduced scale, the system of jointed links which ought, in theory, to be mounted in proximity to the rail.

The arrangement described below is displayed diagrammatically in Fig. 13. Two cables from the two outermost feelers, 1 and 3, respectively, are each connected to the end of a swing bar 11-12, after having been guided by two pulleys fixed to the body of the coach. A cable from the small wheel 2 is led by means of the pulleys 8, 9 and 10 to the extremity, 14, of a second swing bar, the opposite end of which is jointed at a point on the first swing bar, such that the ratio of the distance between the points 12-13 to that between the points 13-11 is the same as the ratio of the distance between wheels 3-2 to that between wheels 2-1.

The displacement of the mid-point of the swing bar 13-14 relatively to the paper band of the recording machine gives the required quantity, that is, one half of the distance of the small wheel 2 from the straight line joining wheels 1 and 3.

The variations in the versines of both rails are recorded simultaneously.

X. — Reproduction of the various indications.

The instruments described above operate inked pens and also the cursors of potentiometers. The pens record the various indications on a band of paper unwinding at 20 cm, 50 cm., 2 m. per kilometre.

Electric wires, fed from the potentiometers, enable the measurement of the

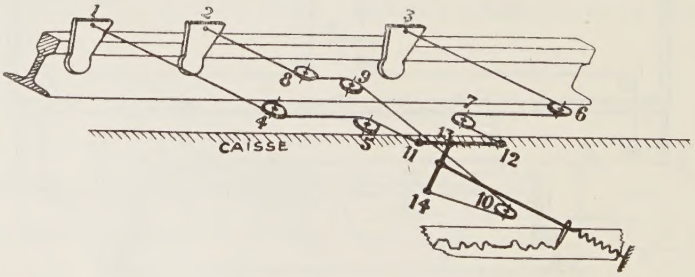

Fig. 13. — Diagram showing the principle of recording versines.

various characteristics of the condition of the track to be conveyed to recording cathode-ray oscillographs in the experimental coaches (described in the *Revue Générale* of January 1938). These coaches, designed for the recording of forces, accelerations, and relative motion of a vehicle under test, can therefore, thanks to the electric transmissions, also register the various characteristics of the track condition. If one places one behind the other the vehicle under investigation, a test car, and the track recording coach, the results of the measurements on the vehicle under test and the characteristics of the track on which the vehicle is running are obtained on the same recording band during the course of a trial. An excellent opportunity is thus afforded of interpreting the riding of vehicles in terms of the condition of the track.

XI. — **Results obtained.**

Since being placed in service, in June 1937, this track recording coach has travelled over the lines of the French National Railways on which trials were made of the stability of various vehicles. Its behaviour has been satisfactory at all times.

We give below (Figs. 14 and 15) two reproductions of records obtained, one on the open road and the other over points and crossings in sidings. In addition we have placed side by side, in Fig. 16, records of the condition of the track and those of the forces set up by a locomotive, registered simultaneously.

The amount of recording done is still insufficient for the reactions of a given type of vehicle to various features of the track to be determined with certainty. The following, however, is a brief account of the principal points :

(1) *Effect of warp (or twist).*

The twist in a track has a fundamental influence on the stability of vehicles, as already explained in the *Revue Générale* for January, 1933. This influence can be summed up as follows :

The primary cause of the hunting of a vehicle is the coning of the tyres. Twist introduces a factor which disturbs the influence of the coning of the tyres, by continually modifying the sinusoidal path due to the coning. Its influence is particularly noticeable when it has a length of several metres, or if there are several successive twists, the effects of which are cumulative.

Twist becomes dangerous when its action enters into resonance with the natural period of the hunting motion of the vehicle. This case, which may seem to be an exceptional one, is in fact of quite frequent occurrence. It would become general if the track were not constantly attended to, because twist is first brought into being by the forces set up by the hunting action and these forces cause partial unseating of the sleepers which in turn build up the hunting action. It is a vicious circle from which there is no escape except through attention to the track.

(2) *Influence of cant.*

There is no doubt that the actual amount of cant has an influence, though a variable one, which depends partly on the radius of curvature of the track and partly on the type and condition of the vehicle. But experience goes to show that variations in the cant (which are, of course, twists) exercise, as we have just seen, a greater influence.

(3) *Effect of slacks.*

If one of the rails dips at a certain point in the track, a twist is formed, the action of which we know. If both rails dip together, the effect so far as the hunting action of the vehicle is concerned, is negligible. The presence of low places results in a reduction of comfort in the rolling stock and an increase in fatigue of its spring gear and of the rails.

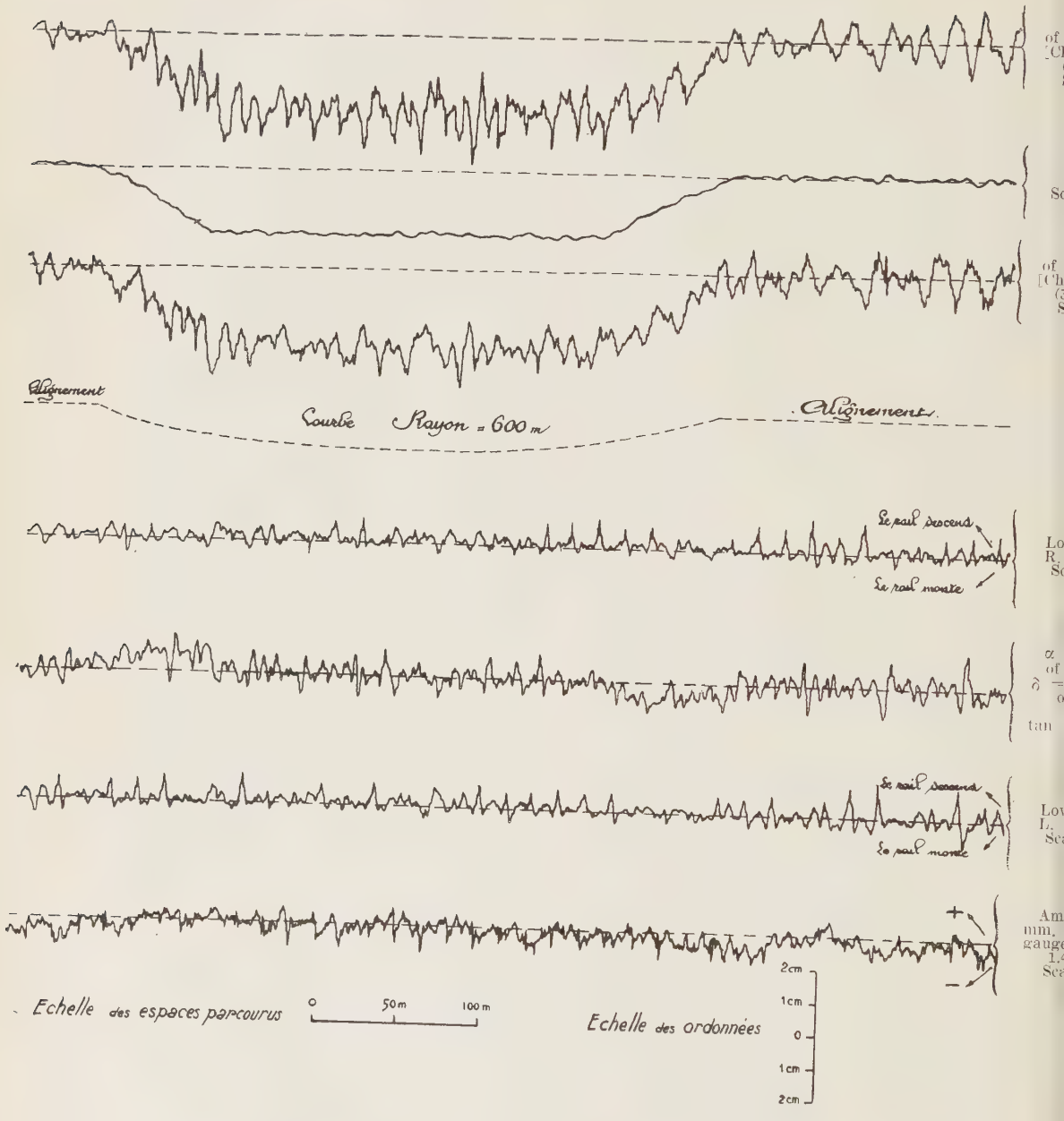

Fig. 14. — Recording coordinates on track in the open.

Note. — Courbe rayon 600 m. = Curve of 30-ch. radius. — Alignement = straight. — Le rail descend = rail dips. — Le rail monte = rail rises. — Echelle des espaces parcourus = horizontal scale (for distance travelled). — Echelle des ordonnées = vertical scale (ordinates).

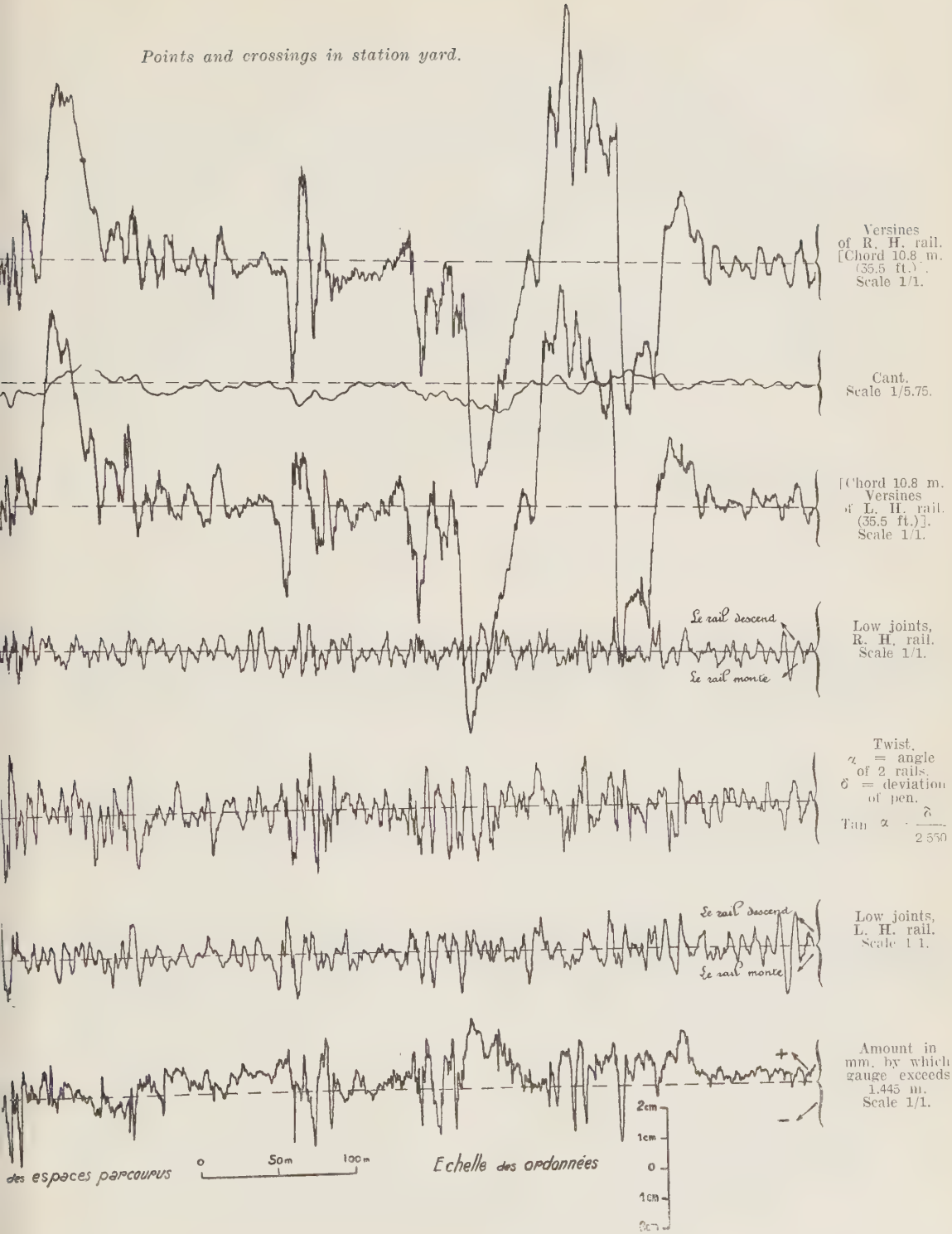
Points and crossings in station yard.
Versines of R. H. rail. [Chord 10.8 m. (35.5 ft.)]. Scale 1/1.
Cant. Scale 1/5.75.
[Chord 10.8 m. Versines of L. H. rail. (35.5 ft.)]. Scale 1/1.
Le rail descend
Le rail monte
Low joints, R. H. rail. Scale 1/1.
Twist. α = angle of 2 rails. δ = deviation of pen. Tan α = δ / 2 550
Le rail descend
Le rail monte
Low joints, L. H. rail. Scale 1/1.
Amount in mm. by which gauge exceeds 1.445 m. Scale 1/1.
+
−
2cm
1cm
0
1cm
2cm
des espaces parcourus
0
50m
100m
Echelle des ordonnées

Fig. 15. — Record of track-coordinates.

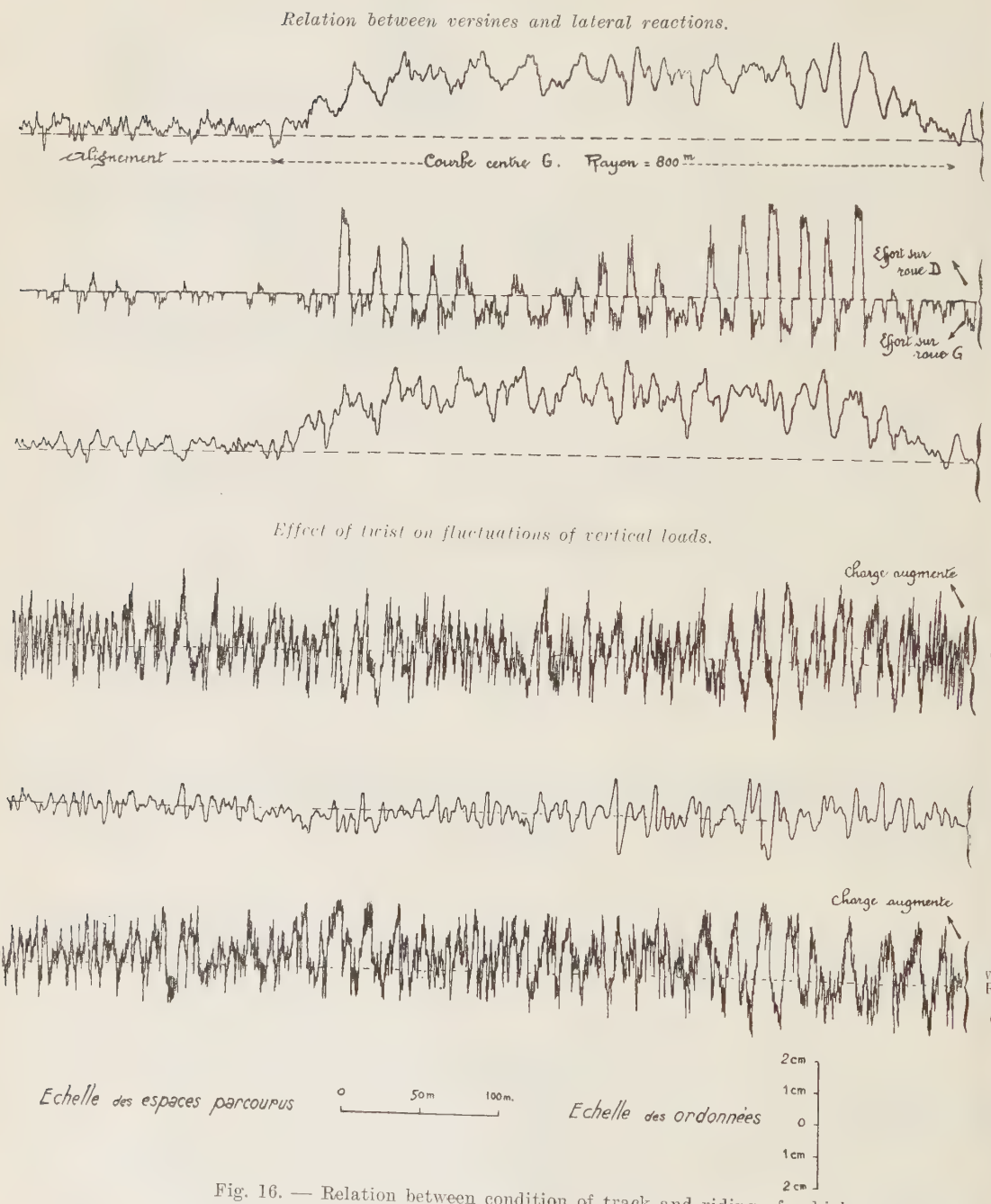

Fig. 16. — Relation between condition of track and riding of vehicles.

Note. — Alignement = straight. — Courbe centre G. Rayon 800 m. = L. H. curve, 40-ch. radius. — Effort sur roue D = force on R. H. wheel. — Charge augmente = load increasing.

(4) *Effect of gauge variations.*

The experience gained so far goes to show that the influence of the gauge of the track, although very important, is nevertheless not quite so great as might be supposed. The transverse oscillations of a vehicle fully absorb the play in the track. They are obviously decreased by any tightening of the gauge, but the period of the hunting action is correspondingly reduced. In fact, under these new conditions the vehicle will roll more frequently on the flange throat; that is, with the effect of increased coning. It has been found, for example, that type E.BB locomotives possess a period of 32 m. (105 ft.) on track of 1.460 m. (4 ft. 9 1/2 in.) gauge; 17 m. (55 ft. 9 in.) on track of 1.445 m. (4 ft. 8 1/4 in.) gauge; and 13 m. (42 ft. 8 in.) on track of 1.435 m. (4 ft. 8 1/2 in.) gauge.

As the result of the period decreasing at the same time as the amplitude, transverse accelerations are not reduced to what might have been expected. In practice it is found that vehicles having little tendency to hunting ride better on track which is tight to gauge. It is desirable, however, in the case of track tight to gauge to verify that the profiles of rails and tyres are such that the wheels ride as little as possible on the flange throat, so as to avoid excessive reduction in the hunting period.

(5) *Effect of versines.*

The average value of the versines on a curve is of only minor importance, but, on the other hand, the variations of the versines exercise a major influence on the transverse reactions of the stock, particularly in the case of vehicles with long wheelbase, especially if the cant does not change at the same time and in the same direction as the versines.

Records of variations in the versines reveal that curved track is not of absolutely constant radius. It varies throughout the curve, fluctuating about an average value (1).

The numerous experiments during which the paths of a point between the rails on each of the axles of 4-8-2 and 4-8-4 locomotives were recorded, have shown that there is a definite position with respect to the track which the centre line of the locomotive main frame will take up for a given radius of curvature. But let the locomotive pass from a curve of radius R (Fig. 17) to a curve of smaller radius *r*.

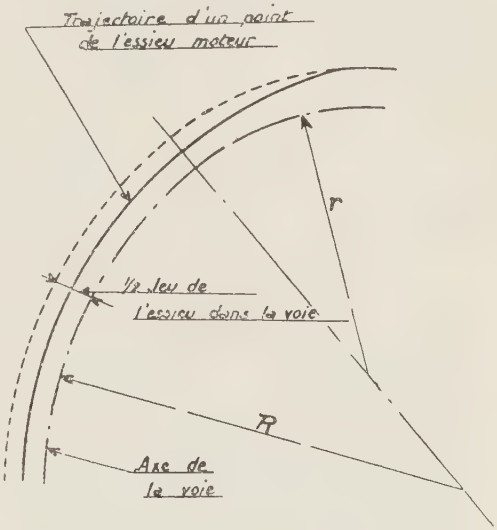

Fig. 17.

Note. — Trajectoire, etc. = path of a point on driving axle. — 1/2 jeu de...= half-play of axle in track. — Axe de la voie = centre-line of track.

On the first curve a point on the leading driving axle moves in a curved path of radius R; at the entry of the curve of radius *r* it is evident that this point will continue in the curve of radius R until, all the play in the track having been taken up, the axle begins to exert a force on the outer rail.

(1) See, in this connection, an article in the 1st February, 1939, number of the *Revue Générale.*

These forces have a harmful effect on the alignment of curves and their general tendency is to intensify any variations in the versines.

CONCLUSIONS.

From the results obtained so far it is evident that there are two different purposes to which this coach can be put.

(1) It can be regarded, in the first place, as a means for studying the effect of the various features representative of the condition of the track, through the medium of the records of the absolute values of cant, versines, and track gauge.

(2) It can equally be employed as a track testing car, since it makes it possible to detect — and locate on the track by the dropping of paint — excessive fluctuations of the absolute characteristics : — twist, slacks, versine variations, the influence of which on the behaviour of vehicles is fundamental, and for which perfectly definite limits of tolerance can be assigned.

The apparatus with which this coach is equipped enables the difficult problem of track maintenance to be studied, in some measure, with greater precision, and the methods resorted to, to be made more systematic, whereas previously the results achieved depended largely on the personnel in charge of maintenance work.

[621.431.72]

Supercharging of diesel engines.

Application of supercharging to railcar and locomotives engines

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(*Revue Générale des Chemins de fer.*)

On several occasions, technical reviews (*Le Génie Civil, La Technique Moderne, Traction Nouvelle,* etc.) have published more or less comprehensive articles on the question of diesel engine supercharging.

The author of the following note sets out, in a very condensed form and without any very involved mathematical explanations, the principles upon which supercharging is based, and gives particulars of the results obtained by the application of these principles to railcar engines.

The article also contains some observations on particular cases (multi-cylinder and high-speed two-stroke engines) where the application of supercharging is not yet definitely established.

A. — General remarks on the theory of supercharging

First of all we must point out that this article comprises two principal parts, dealing with the engines at present used for railcars :

Four-stroke single-acting engines;

Two-stroke single-acting engines.

It is necessary, in fact, as we shall see later, clearly to separate the two types; the conditions of admission and exhaust are quite different and the technical problems to be solved are peculiar to each type.

(1) *Definition of supercharging.*

The power of a diesel engine, all other things being equal, is limited according to the maximum mass of fuel which can be conveniently burned within the cylinder stroke volume. This weight is, moreover, higher than the chemical equation of combustion indicates. Therefore, if the air admitted to the cylinders of the engine is, for some rea-

son, at a lower pressure than the air with which it comes into contact, the combustion is only moderate for the maximum power of the injector pumps. On the other hand, if the air admitted to the cylinders, by means of the devices which are described in the present article, is more highly compressed than the ambient air, the mass of fuel which can be burned is increased, and in the same way the power of the engine is increased.

Supercharging consists essentially in creating supercompression of the intake air and in profiting by certain subsidiary advantages therefrom, which will be explained later.

The rate of supercharging is defined as being the relation of the absolute inlet pressure to absolute atmospheric pressure $\frac{P_r}{P_a}$.

Throughout the following we shall deal with cases in which the supercharging arrangement is permanently connected by a charging pipe with the inlet of the engine (known as continuous supercharging). This is the only method used for railcars.

(2) *Present state of supercharging.*

The first investigations into this subject were started in France, about 1916, by Rateau, with aeroplane engines, which were supercharged in order to keep their power constant at different altitudes. Similar work was undertaken about the same time in Switzerland by Büchi. These two eminent engineers also have to their credit a number of very interesting designs in various branches of engineering (aviation, marine and railway).

Air compression.

The volume of intake air is large and the overpressure is low : a centrifugal blower is therefore utilised in preference to an alternating compressor, better adapted to high pressures and not suitable for high speeds of rotation.

One question immediately presents itself : What is to be the source of power for working this compressor ? Direct or

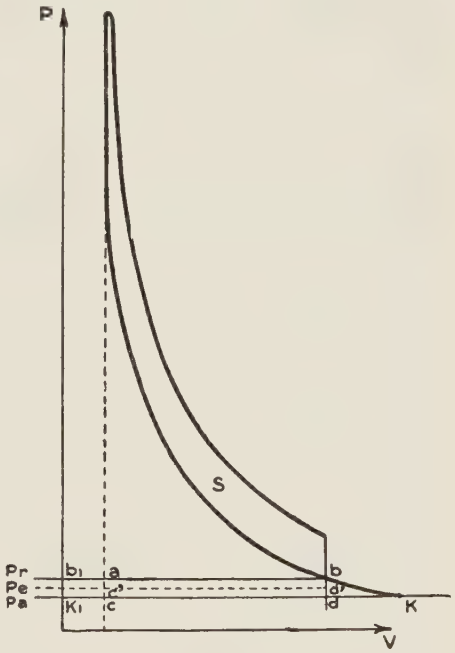


Fig. 1.

indirect, from the drive of the engine to be supercharged, or derived from the residual energy of the exhaust gases ?

The latter solution was indicated by Rateau as long ago as 1916, when he investigated the question of re-establishing the power of aeroplane engines at high altitudes. It is of interest to compare the two systems, at least on the theoretical diagrams. Let :

P_a, = atmospheric pressure;
P_r, = mean charging pressure of the blower;
P_e, = exhaust pressure, assumed to be constant, ahead of the turbine (see Fig. 1).

When an engine supercharged by exhaust gas turbo-blower is provided, the

work done by a unit of the mass of gas is :

$$S + a\ b\ d'\ c'.$$

In the other hypothesis the exhaust counter-pressure is constantly equal to atmospheric pressure, and the work done is :

$$S + a\ b\ d\ c.$$

The apparent gain is therefore equal to the surface $c'\ d'\ d\ c$, but it must be noted that in the first case the work of compressing the air is not performed by the engine but obtained from other sources, whilst in the second case it must be taken from the work of the cycle $S + a\ b\ d\ c$.

This work of compression, by which the air is made to pass from the atmospheric pressure to the inlet pressure, is represented by $b_1\ b\ k\ k_1$.

The *net* work in the second case becomes :

$$S + a\ b\ d\ c - b_1\ b\ k\ k_1.$$

It would therefore appear, from the theoretical diagram, as drawn, that the exhaust gas blower is to be preferred.

This assumes that the delivery pressure of the compressor P , is higher than the mean intake pressure, P_e, of the turbine.

We can show briefly that under certain conditions this is so :

The flow of gas is regulated, according to the law of Bernouilli, as under :

$$w\,d\,v + \frac{d\,p}{\rho} = 0. \quad . \quad . \quad . \quad (1)$$

where

w = speed,
p = pressure,
ρ = specific mass,
v = specific volume.

Now, the energy available, after expansion in the unit of mass, is equal to $\frac{w^2}{2}$.

By integration of (1), this is equal to :

$$-\int \frac{d\,p}{\rho} + \text{Const. C or} - \int_{P_e}^{P_a} v\,d\,p,$$

P_e having the previously defined value,

P_a being the pressure at the end of expansion,

$-\int_{P_e}^{P_a}$ in an adiabatic flow of exponent K from the pressure P_e to the pressure P_a takes the value :

$$\frac{K}{K\text{-}1} \cdot P_e \cdot v\,e \left[1 - \left(\frac{P_a}{P_e}\right)^{\frac{K\text{-}1}{K}} \right]$$

or

$$R \cdot T_e \cdot \frac{K}{K\text{-}1} \left[1 - \left(\frac{P_a}{P_e}\right)^{\frac{K\text{-}1}{K}} \right] . \quad (2)$$

If, however, it is desired to compress from P_a to P_r the unit of mass of another gas whose factor $\frac{C'\,p}{C'\,v}$ is equal to K', the work to be done is, according to the classic formulæ :

$$R' \cdot T_a \frac{K'}{K'\text{-}1} \left[\left(\frac{P_r}{P_a}\right)^{\frac{K'\text{-}1}{K'}} - 1 \right].$$

It should be noted that in a diesel engine, which utilises the mass unit of air and burns with this mass of air a mass ε of fuel, the mass of exhaust gas will be $1 + \varepsilon$.

The available energy in the gas will be :

$$(1 + \varepsilon) \cdot R\,T_e \cdot \frac{K}{K\text{-}1} \left[1 - \left(\frac{P_a}{P_e}\right)^{\frac{K\text{-}1}{K}} \right] (3)$$

Only a portion of this energy is available for compression, due on the one hand to losses reckoned by a coefficient $\varphi < 1$, and, on the other hand to the efficiency ρ_T of the turbine.

In practice, the energy available becomes :

$$\rho_T\,\varphi\,(1 + \varepsilon)\,R \cdot T_e \cdot \frac{K}{K\text{-}1} \left[1 - \left(\frac{P_a}{P_e}\right)^{\frac{K\text{-}1}{K}} \right] (4)$$

Following a similar reasoning for the compressor, letting ρ be the efficiency of the blower and remembering that the mass in question is then equal to the unit, the actual compression energy becomes :

$$R' \cdot T_a \cdot \frac{K'}{K'-1}\left[\left(\frac{P_r}{P_a}\right)^{\frac{K'-1}{K}} - 1\right] . \quad (5)$$

In order to make supercharging possible, it is necessary for the value of the expression (4) to be equal to, or higher than, the corresponding value of the expression (5).

A numerical application of this, taken from experimental measurements, will show us the possibility of this relationship.

Taking :

$T_r = 283°\ P_a = 1.300\ P_a = 1$,
$K' = 1.41$ (air),
$K = 1.34$ (exhaust gas),
$T_e = 1\,020°\ P_e = 1.200$,
$\varphi = 0.8$,

it is sufficient, for the verification of the above conditions, for $\rho_T \cdot \rho_S$, the general efficiency of the installation, to be in the region of 0.58.

We shall further see, that, at the limit, P_r may be equal to P_e, which is equivalent to saying that the air introduced into the engine will be at a pressure equal to the mean exhaust pressure. In other words, the motor will be *scavenged,* and there will be no counter flow.

The limit value of the total efficiency will be given by the equation No. 6.

$$\rho_T \cdot \rho_S \cdot \varphi(1+\varepsilon) R \cdot T_e \frac{K}{K-1}\left[1 - \left(\frac{P_a}{P_e}\right)^{\frac{K-1}{K}}\right] = R' T_a \frac{K'}{K'-1}\left[\left(\frac{P_e}{P_a}\right)^{\frac{K'-1}{K'}} - 1\right] . \quad (6)$$

It is found that : $\rho_T \cdot \rho_S = 0.40$ approximately.

To summarise, *in order that supercharging by exhaust gas turbo-blower may be possible in present day engines, it is necessary for the total efficiency of the supercharging group to have a value of at least 0.5 (approx.).* The two machines composing the group being of the same family, it is sufficient to suppose, for the purposes of the summary investigation visualised, that the efficiency factors are about equal, each being equal to :

$$\sqrt{0.5}, \text{ or } 0.7.$$

All this points to the question : Can a turbine be designed having a total efficiency of 0.7, or a theoretical internal efficiency of about 0.8 ?

We know that in turbo-machines the internal efficiency is a function of the ratio $\frac{u}{C_T}$, u being the peripheric speed of the rotor, and C_T the speed attained by the gas through the turbine distributors.

In single-stage turbines, to which category supercharging turbines belong, it is shown that the maximum internal efficiency obtained for $\frac{u}{C_T}$ is approximately equal to 0.45, and that under these conditions it has the optimum theoretical value of $\frac{4u^2}{C_T^2}$, or about 0.80.

Supercharging is therefore possible, and if the total efficiency exceeds the minimum value of 0.40, the motor may be scavenged, the advantages of which will be explained later.

It must be stated, however, that the question, as here resolved, reaches the limit of possibility, and if it is desired to provide a supercharging pressure clearly in excess of the surrounding pressure, it will be necessary to find some way of combatting the causes of decreased efficiency.

Remarks on the design of the turbine.

The rule mentioned above $\left(\frac{u}{C_T} = 0.45\right)$ implies, according to the calculations, a peripheric speed of 200 m. (656 ft.) per second for the rotor. For its calcul-

ation, it is necessary to take into account the supplementary obstacles as regards dimensions — in theory a turbine, with its lagging, should not take more space transversally than the line of cylinders it feeds; it must be possible to place it within the angles of the two cylinder lines when these are V-arranged, etc.

The number of revolutions N must often exceed 10 000 in order that the theoretical and practical conditions may be fulfilled — with small engines it may reach 30 000.

The actual driving of the turbine offers some very interesting problems :

Throughout the foregoing we have dealt with a hypothesis more theoretical than practical; *it has been assumed that the turbine was fed at a constant pressure P_e; in practice, however, this is impossible;* in fact with an exhaust gas collector of a railcar engine with many cylinders, complex phenomena are produced, due on the one hand to the pulsatory character of the different exhausts, and on the other hand to the de-phasing and its resultant interference.

The constant pressure P_e can only be attained if a high volume of capacity is provided between the engine and the turbine.

The exhaust gases would expand from the pressure P_e to the surrounding pressure, as we have assumed in the theoretical argument above.

At the other extreme, it can be considered that the engine is connected to the turbine by piping of a negligible volume. From this fact, there exists before the distributors a variable pressure.

If we take, for convenience, a single cylinder, at the moment of exhaust opening, we find before the exhaust pipe a pressure of 4 to 5 kgr./cm² (56 to 70 lb./sq. in.), whilst during the return stroke of the piston, the pressure differs very little from that of the surrounding pressure.

These two assumptions cannot be ignored when dealing with the recovery of the energy from the exhaust gases.

The diagram in the low pressure regions will show the fundamental differences (Fig. 2).

The work of air compression is equal to the integral along A A' of $v\ d\ p$ between the pressures P_a and P_r.

First case. — The intermediate capacity is of large volume.

The gas expands in the turbine from the point D_e to the point D_a along the

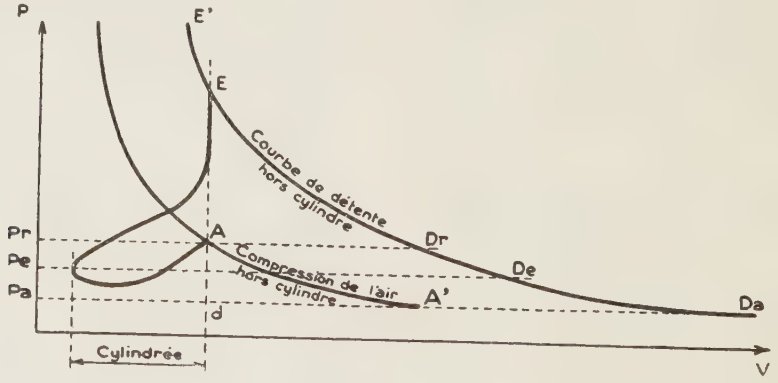


Fig. 2. — Low pressure diagram, inside and outside the cylinder.

Note. — Courbe de détente... = Expansion curve, outside the cylinder. — Compression... = Air compression, outside cylinder. — Cylindrée = Cylinder volume.

curve of expansion and the available work is equal to

$$\int_{D_e}^{D_a} v \, d \, p.$$

It is readily conceived that, apart from the efficiencies, there may be critical values for P_r and P_e such as :

$$\int_{AA'} v \, d \, p = \int_{D_e}^{D_a} v \, d \, p.$$

to which the turbine is limited.

Second case. — The intermediate capacity is of negligible volume.

The communication with the turbine is open from the point E' (exhaust lead) and the gas is expanding according to a complex law.

Theoretically, the work recoverable will be the area of the triangle formed by E D_a d (triangular loss from incomplete expansion). In practice, however, the pressure in advance of the turbine varies; it is higher than P_e during the first moments of exhaust, but remains about atmospheric pressure during the return stroke of the piston. The first phase of exhaust, which is known as « blast », is that during which the cylinder empties rapidly.

In practice, exhausting by blast is not integral; also, it is impossible to recover the whole of the energy corresponding to the triangular loss. The loss increases from the fact that the turbine itself is not a perfectly efficient transformer.

The theoretical recovery from the triangular loss gives a work of approximately 20 % of the work of the real cycle, that of the blast only, 13 to 14 %.

About four-tenths of this work can be recovered in the blower, or 5.6 % of the theoretical work of the cycle; if this energy is now effectively applied to the shaft the percentage will be higher : it is recognised that for one effective H.P. developed in the engine, about 0.065 effective H.P. is thus fed to the turbo-blower for air compression, since we have taken into account in this figure the efficiency of the blower.

Let us now find what pressure can be reached for the air admitted, which is assumed to be taken at atmospheric pressure. Allowing 5.6 m³ (198 cu. ft.) of air per effective H.P./hour, including 0.6 m³ (21 cu. ft.) of scavenge air in the clearance, the available power of 0.065 H.P. will permit this mass of air to be brought to a pressure of 1.360 kgr./cm² (19.3 lb. per sq. in.).

This note on the blast is evidently very summary, but the complete study of it necessitates extended mathematical expositions which are outside the scope of this article.

We will therefore confine ourselves to giving a brief description of the method of calculation.

The matter in hand is the determination of the laws of evacuation of gas filling a given capacity through an orifice of a section varying as the time (1).

According to whether the pressure in the reservoir is $>$ or $<$ the critical pressure, the formula giving the speed u in the reduced section varies. It is therefore necessary to divide the cylinder exhaust into two phases, the first corresponding to the time tc, the second corresponding to the time te. If V is the volume of the capacity,

m the coefficient of orifice contraction, varying with the time t,

v' the specific volume in the section where the speed is u,

S the section, varying with the time t,

it need only be stated that the mass which has been released from the capacity in the time dt is exhausted through the section S.

$$\left[d\left(\frac{V}{r}\right)\right] = \frac{m \, S \, u \, dt}{v'}, \quad V \frac{dv}{v^2} = \frac{m \, S \, u \, dt}{r'}$$

(1) See the work of Mr. Anxionnaz, collaborator with Mr. Rateau (*Bulletin de la Société des Ingénieurs Civils*, Nos. 9 and 10; 1931).

The integration being made according to two determinations,

— the first from *o* to *tc*,

— the second from *tc* to *te*,

the calculation of *u* is made, according to the considered phase, by means of the empirical formulæ resulting from the application of Bernouilli's law to the two expansions separated by the critical pressure.

It might be mechanically possible to utilise the blast by effectively dividing the exhaust into the two phases dealt with above : Two valves would be necessary for this, one, open before the dead centre, would be closed at the moment the critical pressure in the cylinder is attained; this would exhaust into the regenerating turbine. The other, open a few degrees before the opening of the first, would exhaust to the atmosphere.

Use of the compressed air.

If an engine designed to function normally with air at ambient pressure is given air at a higher pressure, the pressure at the end of compression will increase in strict proportion to the pressure of the intake air.

The theoretical corresponding temperatures, which depend solely on the *ratios* of the pressures, will remain the same.

The cyclic efficiency, which depends on the volumetric rate of compression, assumed constant, will also remain constant.

The pressures at the completion of combustion and the completion of exhaust will, however, be multiplied approximately by the rate of supercharging.

The power of the engine, proportionate to the mean pressure of the cycle, will therefore be increased, but at the cost of greater mechanical fatigue in the working parts.

On the other hand, it may be desired that the maximum pressures obtained in the supercharged engine be identical with those on a normal engine. For this it is only necessary slightly to increase the volume of free space at the end of compression and the period of fuel injection.

Naturally the cyclic efficiency is also affected. On the whole it decreases by about 10 %. The temperature of the exhaust therefore increases slightly.

If the matter is confined to these simple considerations, it would seem possible to conclude that, in the two hypotheses, the organic and thermal fatigues of the engine are increased by supercharging.

If the first solution increases the rate of work in the motion towards the top dead centre during the combustion/expansion stroke, fatigue of thermal origin is no longer of negligible amount, since more thermal units are brought into play for the same cooling surface (Fig. 3).

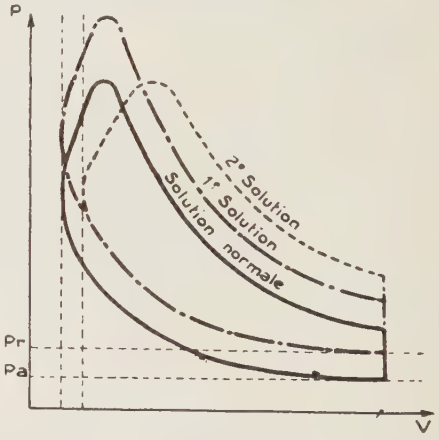


Fig. 3. — Comparative diagrams of a non-supercharged engine and the same engine supercharged (with or without variations in the clearance).

The second solution offers more regard for the motion. In fact the diagram flattens out towards the increasing V's; the piston rod works less heavily on the crank pin, since the zone of maximum effort corresponds to a configuration of the connecting rod/crank system, in which the piston rod approaches the tangent to the circle described by the crank pin.

In this solution, however, the temperature during expansion and exhaust is higher and the risks of insufficient cooling also *appear* to be of equally objectionable nature in this second hypothesis.

In practice, these risks can be annulled by following the undermentioned procedure :

It is known that in a diesel engine there is an appreciable excess of air. Formula (6), however, effectively takes into account this excess of air. Under these conditions it would appear that it can be utilised for *scavenging* the cylinders during a judiciously measured period in which the inlet and exhaust ports remain open simultaneously.

The flux of fresh air in contact with the walls of the cylinder and the piston top will cool them under favourable conditions, given the high circulating speed. Also, it will be seen that, thanks to this high circulating speed, the cooling of the supercharged engine may be as easy, if not easier, than that of an ordinary engine, and that the stresses of a thermal nature may be somewhat reduced, in spite of the increased power.

As a matter of information, we may admit that the cooling water should, in a supercharged engine, contain 80 % of the thermal units needed for a normal engine.

On the other hand, the exhaust gas carries away more heat; in two engines with the same cylinder volume, one supercharged, the other not supercharged, the ratio of the two amounts of heat is approximately 1 : 1.65.

Special characteristics of supercharged engines.

Let us consider the particularly interesting case where the maximum pressure in the supercharged engine remains the same as in the normal engine with which it is comparable. The indispensable modifications would be as follows :

(a) *Increased volume of the compression chamber.* — It may be admitted that the decreased volumetric rate of compression consequent upon this increase can be limited to about 6 %. Under these conditions the theoretical cyclic efficiency is hardly reduced at all.

We have already drawn attention to the necessity for leaving the inlet and exhaust ports simultaneously open at the top dead centre so as to achieve scavenging in the cylinder.

In a normal engine, the piston may at the top dead centre be at a greatly reduced distance from the bottom of the cylinder head. In a supercharged engine, however, there would be a risk of contact between the piston and the valve heads. It may be possible to obviate this risk by incorporating recesses in the piston heads, a step which also results in the indispensable reduction in the rate of compression.

(b) *Modification of the valve gear.* — It is necessary to delay the end of the admission, so as to « cross » the inlet and exhaust valves.

The values of the angles of operation and the setting of the valves depend on the engine in question; it can, however, be admitted that, measured on the crank shaft, the angle of simultaneous opening of the two valves must be about 80 to 100 degrees, the exhaust opening lead being approximately equal to the inlet closing lag.

We shall see in the paragraph relating to multi-cylinder engines that other modifications are necessary to increase turbine efficiency.

(c) *Modifications to the injection.* — It is obviously necessary for the fuel pump to be of ample capacity. At the same time it will be beneficial to design the injector cams with a special profile in order that the admission of the fuel may be prolonged.

Power and consumption.

What are the practical results to be

obtained as regards power and specific consumption ?

The use of an exhaust-gas turbo-blower allows feeding with air having a pressure of 0.300 kgr./cm² (4.3 lb./sq. in.) over atmospheric pressure. The ratio of admission pressures being 1.3, the proportion of the masses of air taken in is approximately the same; the power ratio, all other things being equal, will also be the same, 1.3.

The problem to be solved is to know whether better results can be obtained or not.

Let us first note that in a normal engine it is impossible to burn the fuel conveniently without an excess of air which, in the cycle, has practically no value.

In an engine supercharged by exhaust-gas turbo-blower there is a scavenging of the cylinders and consequently the air is not charged with the exhaust residue from the preceding cylinder charge. As this scavenging costs nothing, seeing that it is obtained from regeneration of the exhaust energy, a better combustion may be envisaged, and correlatively an increase in the amount of energy provided by a given mass of fuel. The influence on specific consumption therefore seems to be favourable.

On the other hand, we must remember that if the engine works at a constant maximum pressure, the mechanical losses do not vary — or vary only slightly. As they occur with a higher effective power, however, the mechanical efficiency of the engine is increased; this is a further favourable factor.

It is true that the cyclic efficiency must theoretically decrease; in a normal engine it would be 0.52, for example; in a supercharged motor it would be 0.57. These values are much higher than the practical degrees of efficiency. In fact, these are in the region of 0.35; that means that there are other elements, apart from mechanical efficiency, which decrease efficiency; effect of the walls, deformation of the diagrams... All our previous remarks on the favourable effects of the air blast which, on the one hand lowers the internal temperature and consequently the heat exchanges and on the other assures correct charging, provide cause for believing that there will be a sufficiently large compensation to repay at least the 5 % loss in cyclic efficiency.

This is actually so; with an engine supercharged from the exhaust gas, an effective power of more than 50 % in excess of the power of a similar normal engine may be reached.

Nor is an increase in specific consumption to be feared. But precise details must be given here : It is noted, in fact, that the influence of supercharging is not very marked at low powers. In order that the turbine may show appreciable results it is necessary that a sufficient flow of gases should pass through it, otherwise the cross sections of its passages are ill adapted, the speeds of flow are too low, and the transformed power available for supercharging drops rapidly.

From this fact, the supercharged engine will have a higher specific consumption at low loads than a normal engine, since we have shewn that the favourable factors are not very active whereas the unfavourable factors (drop in cyclic efficiency, rise in exhaust back-pressure...) are in full play.

On the other hand, with higher loads the combustion is, in a way, automatically regulated; the turbine is then capable of a higher power; the blower supplies the air at an increased pressure and the mass of combustion air introduced thus suits itself to the amount of fuel injected. The combustion remains good, even on overload, contrary to experience with a normal engine.

The curve of specific consumption in terms of the power then gives a very flat minimum.

This being so, we may trace on the same diagram the curves C, C_1 and C_2

for a normal engine of P_n power, for a supercharged engine of 1.5 P_n power, and for a normal engine of 1.5 P_n power (Fig. 4).

In practice, the minimum values of consumption are almost identical, C and C_2 have also the same form but C_1 is flatter, in view of the preceding remark.

We see that the supercharged engine accommodates itself very well to the load variations which are usual in service on railcars and diesel locomotives, and that from this point of view it is better than a normal engine.

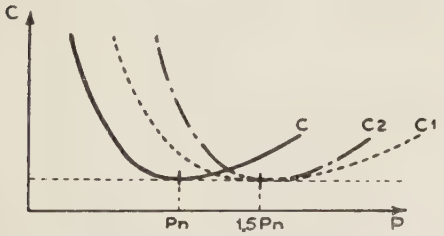


Fig. 4. — Comparative consumption curves of two normal engines of P_n and 1.5 P_n power respectively, and a supercharged engine with a power of 1.5 P_n.

A comparison of the two curves C_1 and C_2 is particularly instructive. We must obviously be prepared to make some sacrifice at very low loads by comparison with the normal engine of P_n power, but these sacrifices are much less than would be imposed during the same periods by the use of a normal engine of 1.5 P_n power.

Two-stroke engine.

In a two-stroke cycle there are critical periods round the bottom dead centre and during the return stroke. At this moment the residual gas which has not yet been exhausted, and the fresh intaken air are extant at the same time in the cylinder.

Many arrangements have been devised to obviate the drawbacks of this state of affairs : partitioned pistons, duplication of the ports, controlled admission, etc.

It still remains true, however, that the exhaust and admission in these engines are very sensitive, particularly the former. Scavenging is an absolute necessity.

Let us therefore examine the evolution of the gas from the time the exhaust ports are opened.

In order that the drainage of the cylinders may be facilitated, either by the existence of a high pressure at the moment of opening the exhaust ports, or by a sufficiently prolonged scavenging, the stroke B C corresponds to a large proportion of the total stroke A C (20 to 25 %) (Fig. 5).

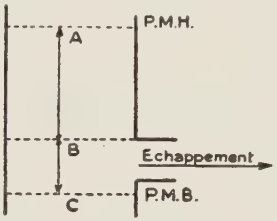


Fig. 5.

Note. — Echappement = exhaust. — P. M. H. = top dead centre. — P. M. B. = bottom dead centre.

The pressure is relatively high when the piston is at B; it exceeds by 1.5 kgr./cm² (21.3 lb./sq. in.) that existing at the opening of the exhaust port in a four-stroke engine and the temperature of the gas is correspondingly higher, by at least 100 %.

Then, the energy available in the exhaust gases corresponding to the triangular loss is greater than in the corresponding four-stroke.

In the latter case, however, we have seen that by utilising the blast we can regenerate a power of compression, per effective H.P., equal to 0.065 H.P.

In the two-stroke, following the same hypotheses, this horse-power would be 0.112.

The question now arises of utilising this to the best advantage.

For this we note that the air neces-

sary for the running of a two-stroke is composed for one part of the scavenge air, which may be at a relatively low pressure, and another part of combustion air which must reach as high a pressure as possible.

Let us again take a figure of 5 m³ of intake air per effective H.P./hour as in the case of the four-stroke; but in place of 0.6 m³ necessary for scavenging the clearance, let us take it that 3 m³ at atmospheric pressure are necessary for scavenging the cylinders. As in this case the pressure of the scavenge air will have to be 1.150 kgr./cm², the available energy of 0.112 H.P. will be utilised :

— on the one hand, for the compression of 3 m³ from 1 kgr./cm² to 1.150 kgr./cm²;

— on the other, for the compression of 5 m³ from 1 kgr./cm² to P_r.

P_r being the unknown pressure of admission,

0.112 H.P. is equivalent to 75 × 3 600 × 0.112 kgr. or 30 420 kgrm.

If air is taken at the temperature T_o and at the specific volume, the feed pressure P_r will be given by the formula :

$$30\,420 = \frac{K}{K-1} R\ T_o \left[\frac{3}{0.83} (1.15^{\frac{K-1}{K}} - 1) + \frac{5}{0.83} (P_r^{\frac{K-1}{K}} - 1) \right]$$

For example, if K = 1.41, we have R = 29.27, V_o = 0.83 with T_o = 293°, it is found that P_r = 1.620 kgr./cm².

On the contrary, if all the air necessary is compressed to the same degree, whether it be used for scavenging or combustion, the pressure P'_r then obtained will be inferior to P_r .

The diagram shewn in figure 6 summarises the evolution of air in both hypotheses.

P'_r is then calculated by the formula :

$$30\,420 = \frac{8\ K}{0.83\ K - 1} R\ T_o \left[(P'_r)^{\frac{K-1}{K}} - 1 \right]$$

P'_r = 1.420 kgr./cm² (Fig. 6).

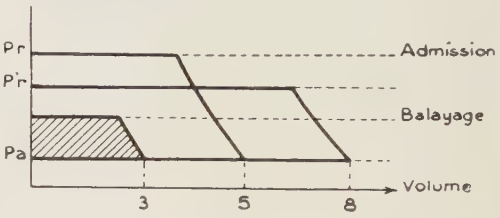


Fig. 6. — Compression diagrams for two-stroke engine, scavenged and supercharged.

Note. — Admission = Intake. — Balayage = scavenging.

These two solutions would, moreover, point to two entirely different mechanical arrangements.

It would be necessary in the first to utilise two compressors, one for scavenging and one for feed, the supply pressures of which would be 1.150 and 1.620 kgr./cm² respectively (1).

In the second case a single compressor would be sufficient.

This being so, let us consider the design of a two-stroke motor supercharged to the maximum amount (Fig. 7).

As the blast only is used, the exhaust may be divided into two flows :

— the first leading into the compressor,

— the second discharging to free air.

This result could be attained by providing split exhaust nozzles, and intake ports distinct from the scavenging ports.

The upper exhaust ports, opened at

(1) The pressure necessary for compression may be slightly reduced, providing a low pressure compressor for the whole of the necessary air and putting the high-pressure compressor as second stage on part of the feed of the low-pressure compressor.

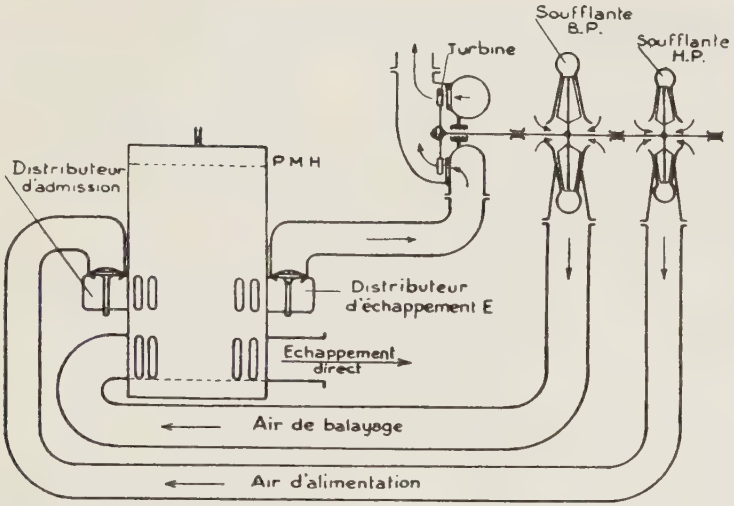


Fig. 7. — Theoretical diagram of a two-stroke engine, scavenged and supercharged.

Note. — Distributeur d'admission = Admission valve. — Soufflante B.P. (H.P.) = Low (high) pressure turbo-blower. — Distributeur d'échappement = exhaust valve. — Echappement direct = direct exhaust. — Air de balayage = scavenging air. — Air d'alimentation = feed air.

the end of expansion by a valve, would take the blast and lead into the turbine. They would be closed at the completion of the blast.

The lower fixed ports are used for exhaust and scavenging as in an ordinary engine, and connected to the low-pressure compressor. The admission ports located in the cylinder at the same level as the upper exhaust ports are connected to the high-pressure compressor. They are opened at the end of scavenging and at the commencement of compression by a sleeve or valve.

The diagram of such an engine, shewn in Figure 7, is obviously theoretical, and to put it into practice would entail real difficulties, as well as undeniable mechanical complications.

The most delicate problem would, without doubt, be the design of the exhaust distributor E, intended to isolate the blast. The temperature of the gas, which exceeds 500° C. in a four-stroke engine, would reach 700° C. For this reason a valve would appear preferable to a sleeve.

It would also be necessary for the material from which this item was made to be selected with particular care. The recent improvements in the construction of valves for aeroplane engines would possibly prove beneficial; these special valves are hollow and cooling is quickened by filling the interior cavity with sodium. The behaviour of the valve seats is improved by stelliting.

Finally it is to be noted, to the credit of this engine, that the separation of the blast may lead to an increase in the working pressure in the cylinder by the creation of a slight vacuum above the piston, immediately after the expulsion of the blast (Kadenacy effect).

In order to profit from this, the opening of the scavenging valve could probably be retarded a little, so that it is positively opened after the closure of E.

Possibilities of the supercharged two-stroke engine.

It is of interest to compare the power, for equal cylinder capacity and number of revolutions, provided by a super-

charged two-stroke engine as outlined above, with that given by a four-stroke normal or supercharged engine.

If the power of a normal four-stroke engine be taken as 1, the same engine when supercharged gives a power of 1.3, which may be increased to 1.5 by effective cooling due to scavenging, improved combustion and increased mechanical efficiency.

The normal two-stroke engine, with scavenging at 1.150 kgr./cm², according to the average of experimental results, gives a power output of 1.75.

If air is admitted at a previously calculated pressure of 1.6 kgr./cm² the supercharged two-stroke would have a theoretical power of :

$$\frac{1.75 \times 1.6}{1.15} = 2.44 \text{ (approx.)}.$$

If it is admitted that the losses which arise from the valve gear then to be provided offset the increased mechanical efficiency, and that thermal fatigue is reduced and combustion improved, the supplementary increase in power, equal to 1.5/1.3, which is found with the four-stroke, will in this case be reduced slightly since all the factors are not so favourable as in the case of the four-stroke engine.

Let us take it that the increase would be 10 % on the coefficient of 2.44. The power of the supercharged two-stroke would then be $2.44 \times 1.10 = 2.68$ approximately.

The comparison may be summarised in the following table :

Four-stroke, normal	1
Four-stroke, supercharged . .	1.5
Two-stroke, normal	1.75
Two-stroke, supercharged . .	2.68

These figures shew the benefit to be derived from pursuing the investigations undertaken for the integral supercharging of two-stroke engines, which gives the maximum power/weight ratio, a very important condition in railcars, where weight and bulk must be reduced as much as possible.

Comparison of weights per H.P.

The power/weight ratios, compared with four-stroke engines described above, are not absolutely proportional to the figures shewn in the foregoing table.

Indeed, it is necessary in the case of supercharged two or four-stroke engines, to add to the weight of the engines the weight of the accessories, which are very complicated in the case of two-stroke engines; the piping, too, is more complicated, and consequently heavier.

From this point of view let us compare two engines specially suitable for railcars : the Maybach GO 56 type, of 410-H.P. at 1 400 r.p.m., and C.L.M. 8 DV 120 type, of 500 H.P. at 1 500 r.p.m.

The supercharging arrangements, comprising two blowers in parallel, used on the GO 56 engine weigh about 250 kgr. (550 lb.).

The engine thus equipped gives a continuous output of 550 H.P. and weighs 2 350 kgr. (5 180 lb.) (1).

A similar engine, but designed specially for supercharging, the GO 6, provided with a single blower, gives a continuous power output of 600 H.P., and weighs 2 300 kgr. (5 070 lb.).

On an engine of the C.L.M. 8 DV 120 type, the provision of a two-pressure turbo-blower and a special valve gear would involve an increase in weight of 200 kgr. (440 lb.). This is relatively low, because the mechanically-driven rotary compressor which is at present fitted could be dispensed with. A further advantage is that the power taken by this compressor becomes available and can be used for motive power.

This compressor charges 8 m³ (282.5 cu. ft.) per H.P./hour at an average pressure of 1.300 kgr./cm² (18.5 lb./sq. ft.).

(1) These figures have been obtained from a bench test on a Rateau-supercharged engine, which gave a peak output of 640 H.P.

The *theoretical* hourly energy required is equal, taking the hypothesis already set out in the preceding calculations, to :

$$\frac{8}{0\,83}\cdot\frac{K}{K-1}RT_o\,(1\,300)^{\frac{K-1}{K}}-1=19\,800\,\text{kgr.}$$

(approx.), taking K = 1.41, R= 29.27, T_o = 293°.

The power of compression *p* per effective H.P. on the shaft, taking account of an efficiency of approximately 0.60 for the compressor and its drive, is :

$$\frac{19\,800}{270\,000}\times\frac{1}{0.60}=0.12\ \text{H P.}$$

If for comparison we bring down to 1 400 the number of r.p.m. of an engine similar in power to the 8 DV 120, and bearing in mind the ratio of specific powers given in the preceding table, the power of the supercharged engine would be :

$$\frac{1\,400}{1\,500}\times\frac{2.68}{1.75}\times(1+p)\times500=775\ \text{H.P.}$$

(approx.).

The following table shews the comparative weights per H.P. :

Type of engine.	Certified effective H.P.	Normal horse-power at 1 400 r.p.m.	Weight Kgr. *(Lb.)*	Weight per H.P kgr. *(Lb.)*
GO 56	410	410	2 100 *(4 630)*	5.34 *(11.67)*
GO 6	600	600	2 300 *(5 070)*	3.83 *(8.44)*
GO 56, supercharged	550	550	2 350 *(5 180)*	4.27 *(9.41)*
8 DV 120	500	466	2 300 *(5 070)*	4.93 *(10.87)*
8 DV 120, supercharged . .	?	775	2 500 *(5 510)*	3.24 *(7.14)*

An inspection of this table shews the advantages to be derived from the use of supercharged engines on railcars and diesel locomotives, where weight and space are limited. The supercharged two-stroke engine, which however has not yet been built industrially, is the most suitable from this aspect. The indicated values, obtained from calculation or by unconfirmed expectations are obviously open to discussion, but there is no doubt that the subject must be investigated further.

Effect on silencers.

Supercharging by turbo-blower offers a subsidiary, but by no means negligible, advantage in that it is possible to reduce the dimensions of the silencer applied to the engine, that is, the partial muffling of exhaust noises.

This phenomenon, however, is not very marked when dealing with fast multi-cylinder engines, the exhaust of which is very strong and noisy.

Application to multi-cylinder engines.

The remarks made above on the use of the blast concern essentially single-cylinder engines. The same conclusions remain valid when the number of cylinders is such that the blasts may be considered as definitely separate, and when there is no appreciable interference between the phases of the exhaust and the intakes of several cylinders.

It is therefore necessary to consider how this can be achieved in practice.

The separation of the blasts takes place in a four-cylinder in line four-stroke engine; the four blasts are spaced at regular intervals over the 720° of the cycle.

The maximum number of cylinders which can exhaust into a single collector is consequently four.

Is the second condition fulfilled ?

Let us make a diagram of the distribution in terms of the cyclic angles in

Diagram of crankshaft.

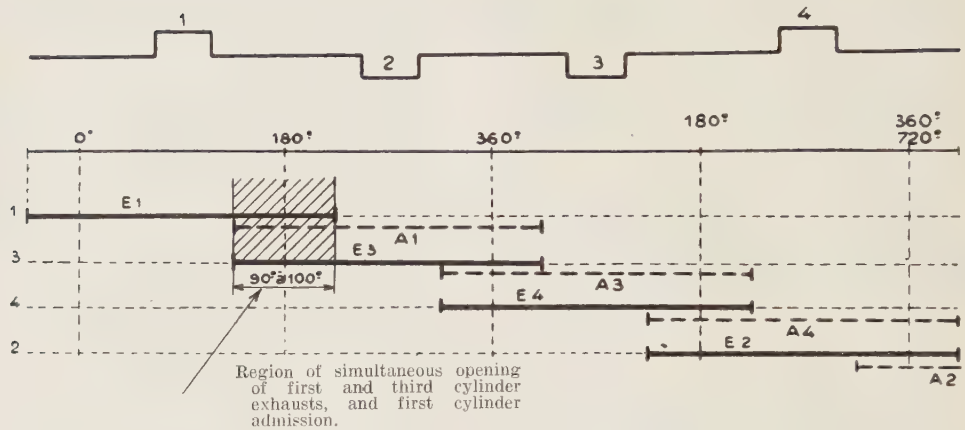


Fig. 8. — Sketch of the distribution of a four-cylinder four-stroke supercharged engine.

a four-cylinder four-stroke engine, igniting in 1 3 4 2 order (Fig. 8), and having a conventional design of crank shaft; the phase difference is then 180°.

We notice the following fact : on account of the « crossing » of the valves necessary for scavenging, over an angle of about 100°, admission to the first cylinder coincides with the exhaust from the third cylinder, also over an angle of about 100°. Back-pressure is to be feared, as the exhaust gases of the third cylinder, being still at high pressure, might enter the first cylinder.

Obviously, this as it were geometric reasoning may be upset by practical experience. In fact, the communication offered by the simultaneous opening of the exhaust valve of cylinder 3 and the inlet valve of cylinder 1 is greatly reduced since these two valves scarcely leave their seats.

Moreover, between cylinder 1 and cylinder 3 there is always a considerable volume of piping, which volume tends to restrain possible cross-flow of gas, which would also have to take place in a very short space of time.

Let us now draw up the same diagram for a three-cylinder (Fig. 9) engine having a three-crank shaft with cranks at 120° and igniting in 1 3 2 order; we note that the angular range of coincidence is, in practice, negligible and the risk of interference almost nil.

It is therefore beneficial to group only

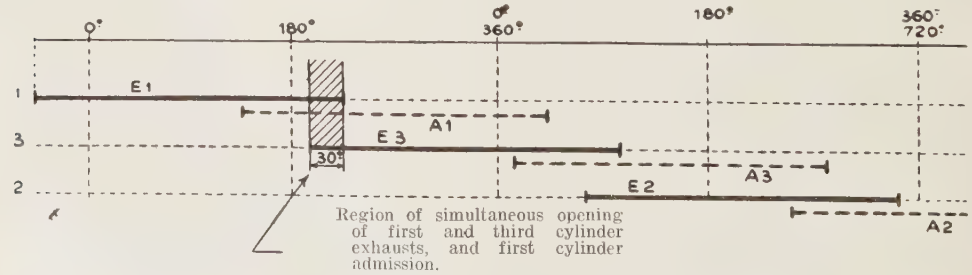


Fig. 9. — Sketch of the distribution of a three-cylinder four-stroke supercharged engine.

three cylinders on a single collector, if it is desired to profit from all the advantages of supercharging.

By taking certain precautions, however, four cylinders may be grouped together, as is done by Büchi with eight-cylinder engines. It is possible, for example, slightly to delay the opening of the exhaust ports.

Doctrine on this delicate point is not yet definite, and is the subject of much controversy.

Similar conditions apply to six-in-line or V-type 12-cylinder engines.

It is then desirable to group the exhaust from three cylinders in one collector, these cylinders being chosen so that the blasts are produced at equal intervals in the cycle.

These remarks also apply to two-stroke motors. It must, however, be borne in mind that the blasts are only produced once in each cylinder per revolution. In this case it is advantageous to group only two cylinders in one collector.

It is further necessary to note that, the feeder turbines being with partial injection, two collectors, for example, corresponding to each group of cylinders may discharge into the same turbine, one at 180° from the other.

This arrangement is also not without advantage from the turbine efficiency point of view (ventilation effect).

B. — Technical description of turbo-blowers for supercharging.

General arrangement.

Supercharging groups may be arranged either on the horizontal or vertical plane. The second arrangement is convenient for railcar engines, since the space occupied by the engine is not increased in length. The group may be placed in the angle of the V, as shewn in figure 10.

The small capacity of the very short exhaust pipes is a factor which helps to increase the efficiency of the turbine.

This arrangement has been followed by Büchi on a Maybach GO 6 engine, in service on the Reichsbahn.

T. Exhaust collector.
G. Turbo-blower group.
E. Exhaust.

Fig. 10.

Rateau-equipped diesel locomotives for the Congo-Océan Company are similarly arranged; in these locomotives the groups are placed above the engine where there is available space.

The mounting of one of these groups necessitates special precautions, particularly when they are installed at one end of an engine, as shewn in figure 11.

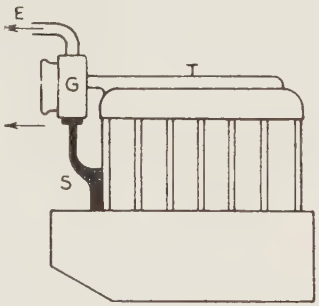


Fig. 11.

The piping T, flanged on the engine, is subject to very high temperatures. The expansions are transmitted to the free end which is connected to the group G, which tends to move in the direction of the arrow. The support S must therefore be flexible in the same direction whereas it must be rigid in a perpendicular direction.

A flexible support is particularly recommended for small or average powers. For large engines, an expansion joint in the piping might be preferable.

These joints must be given particular attention, otherwise any leaks would reduce the mass of gas passing into the turbine, and hence the efficacy of the group.

Rotor.

Turbines, in all cases, comprise one rotor wheel, with partial admission; each of the distributor blade groups corresponds, as we have seen, to an exhaust collector.

The calculation and design of a turbine provide a very delicate problem for reasons of various kinds :

(*a*) Determination of the angle of the blades results from the form of the speed triangles (A.B.D. and A.B.D_1), *u* being the circumferential speed, C_T the absolute velocity on emerging from the distributors, C'_T being the absolute velocity on leaving the rotor (Fig. 12).

A construction of this kind is applicable to the whole of the vanes only if *u* and C_T are nearly constant for its

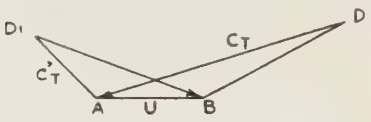


Fig. 12.

full height, which is not the case with turbo-blowers.

u, in fact, increases in an appreciable manner in proportion to the distance from the centre, the small vane having a comparatively large height in comparison with the diameter of the wheel.

As for C , it varies :

on the one hand in the time, the pressure ahead of the distributors not being constant,

on the other hand, in accordance with the location of the gas flow, in the section *a b c d* of the vanes (Fig. 13).

This is limited by two radial lines of intersection *ac, bd,* which present be-

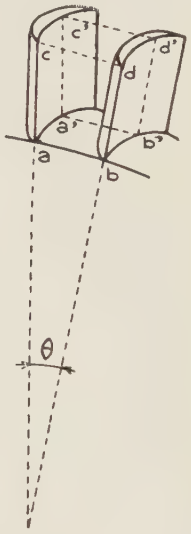


Fig. 13.

tween themselves an angle of contingence Θ which must be taken into account when dealing with small wheels, such as those which we now have under consideration.

For these reasons, the distribution of gas is not constant in the section of mixtilinear trapezoidal shape which is offered to it and the filling is not uniform. Further, the pressure instead of being constant in a section *a' b' c' d'* as the simple theory would appear to show, is higher in the region near *a' c'* where the impact takes place, whilst eddies are produced at *b' d'*.

Under these conditions, the vanes of certain turbines used for supercharging would have to have angles and sections varying according to the distance from the centre : the difficulty of manufacturing such blades is obvious, and consequently the calculations are not often carried so far.

(*b*) The rotary elements of gas turbines are subject to high mechanical stresses, due in part to the centrifugal force, which are still more difficult to bear, as the temperature of the vanes is high. Worse still, the temperature is not constant over the whole of the wheel, the centre being much less hot (by several hundred degrees).

Thermal stresses are thus created, which compound with the mechanical stresses. The wheel and vanes must therefore be made of metal of special composition, with exceptional characteristics.

High-tensile steels with a high nickel and chrome content, with the addition of manganese or tungsten (4 %), are usually chosen.

They have the following characteristic values :

Cold	Y. P.	36 kgr./mm² *(22.9 tons/in.²)*
	T. S.	75 kgr./mm² *(47.6 tons/in.²)*
	E	25
at 800° C	Y. P.	22 kgr./mm² *(14.0 tons/in.²)*
	T. S.	25 kgr./mm² *(15.9 tons/in.²)*

They are very resistant when hot; at 600° C. a test piece of this class of metal, subjected to a pull of 18 kgr./mm² (11.4 tons/sq. in.) broke at the end of about 100 hours, whilst a test piece of semi-hard steel having similar characteristics when cold, broke in ten minutes.

The specification for this steel demands a further supplementary characteristic; the *limit of viscosity,* defined as being the load per mm² giving between the 25th and 35th hours an elongation of 1/1000 per cent per hour — at 600° C. this limit often exceeds 10 kgr./mm² (6.3 tons/in²).

As a measure of precaution, gas turbine constructors do not place any great trust in the physico-mechanical properties of the material used. They have provided cooling devices for the wheel and more particularly for the vanes. To this end, use can be made of a bye-pass on the compressor feed, which leads into the wheel case, about its centre. Cases are on record where the blades have been hollowed, and the air drawn in as mentioned above.

(*c*) We pointed out that the speed of rotation of turbo-blowers must be very high. It is therefore important to balance with care the revolving mass, to carefully select dimensions of the shaft so that it rotates at a speed well away from its critical speed.

Generally, the shaft is called « rigid », that is, the normal number of revolutions is above the critical number.

According to Föppl's formula this critical speed is proportional to $\frac{1}{\sqrt{f}}$, f being the static flexion of the shaft bearing the turbine discs and the blower, and carried on its bearings.

It is therefore important to reduce this flexion as much as possible.

Good results may be obtained in this direction by arranging one of the discs in an overhanging position and the other close to one of the bearings. The weight of the first produces a bending counter-moment which reduces the deflection. Moreover, if there is a deflection of the shaft, the centrifugal force $dmr^2 \omega^2$, applied to the element dm of the disc D_1, produces a straightening moment proportional to $dmr^2 \omega^2$. The straightening moment calculated by integration is consequently proportional to the polar inertia of the disc (Fig. 14).

The turbine disc is of forged steel and the vanes are often milled from the solid. In wheels for low power, machining of very small blades would be practically impossible. In this case, the vanes are fixed on the disc according to the particular practice of each con-

structor. This type of mounting has, moreover, supplementary advantages from the point of view of vibration, as compared with vanes milled from the solid.

The blower wheel is also of forged steel, and is mounted on the shaft by conical hafting.

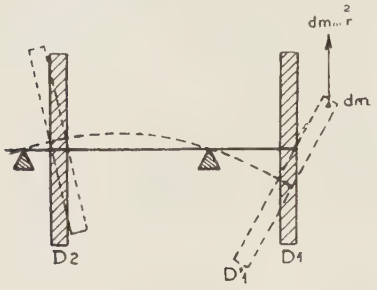


Fig. 14.

Stator.

The turbine casing is of cast steel and steel plating. It carries the fastening brackets for the group on its support and the horizontal flange for the exhaust piping, this being normally directed upwards. It is heavily lagged to avoid heat radiation, and is provided with a blued-steel plate envelope.

The body of the blower is of light metal, in two parts, one corresponding to the section, the other to the intake.

The body is obviously not lagged, and is further isolated from the turbine part, which has a higher temperature, by a screen.

Longitudinal section.

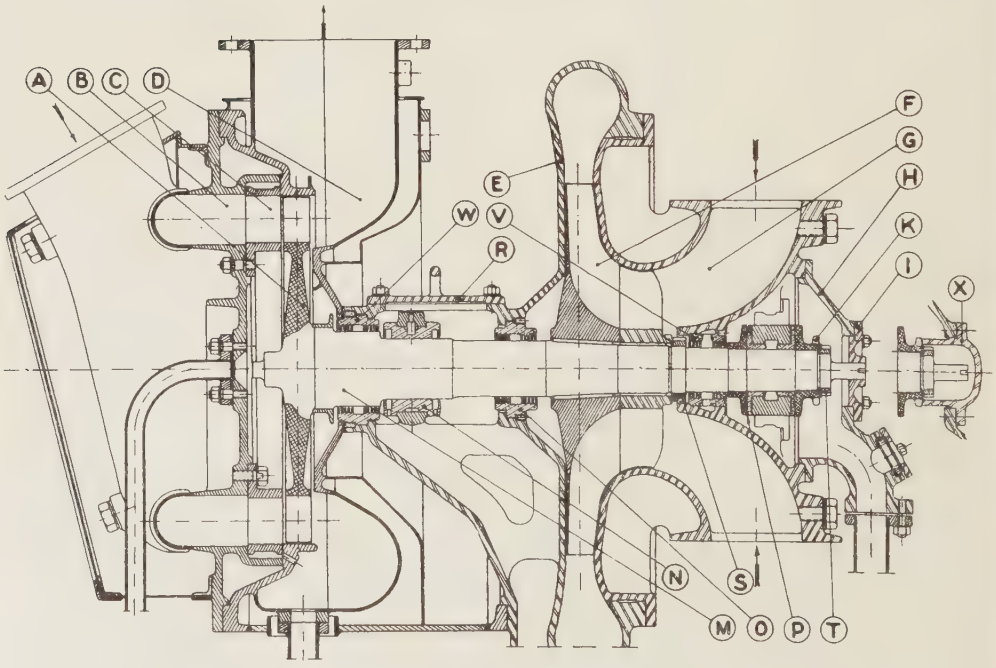


Fig. 15. — Exhaust-gas Rateau turbo-blower for supercharging diesel engines.

A = Turbine wheel.
B = Inlet casing.
C = Distribution nozzles.
D = Exhaust casing.
E = Feed casing.
F = Blower wheel.
G = Suction casing.
H = Cover plate, incorporating oil ejection.
I = Cover plate.
K = Rotor locking stops.
M = Rotor.
N = Plain bearing.
O = Labyrinth packing.
P = Thrust block.
R = Removable cover.
S = Tightening screws.
T = Locking screw.
V = Packing.
W = Labyrinth packing.
X = Rotor locking device.

Bearings.

Both arrangements, plain bearings and ball bearings, are used by constructors. They may be provided with check blocks to resist axial thrust of the rotor.

Lubrication is assured by a feed pipe taken from the outlet of the diesel oil filter, which must be adapted for this supplementary function.

The feed pressure must be between 0.800 and 3 kgr./cm² (11.4 and 42.7 lb./in²) effective.

When supercharging is applied subsequently to a diesel engine not originally so equipped, it may be advisable to provide a separate circuit for the group bearings, to avoid disturbing the delicate lubrication arrangements of the engine.

Packings.

The packings are of the labyrinth type and are cooled by air by-passed from the blower. They are provided with deflectors to prevent gas or oil flowing back.

Drainage.

In traction engines which exhaust upwards, it is necessary to prevent water getting into the turbine (rain or condensation). A permanent drain cock is therefore provided at the bottom point of the turbine casing.

Stopping the rotor.

A defect in the turbo-blower must not necessarily mean stopping the engine. For railcar or diesel locomotive service, a stopping device is provided which consists mainly of a cover plate with two stops which lodge in two recesses in the thrust collar.

This description may be followed, item by item, in figure 15.

Figures 16 to 18 give details of some

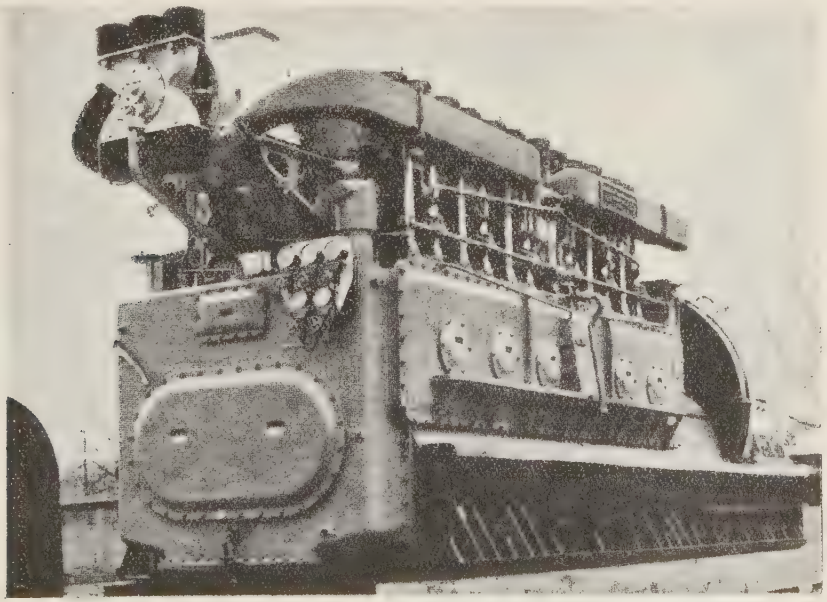


Fig. 16. — P.L.M. diesel-electric locomotive (1937).
Sulzer 2 200-h.p. engine, supercharged by Rateau turbo-blower.

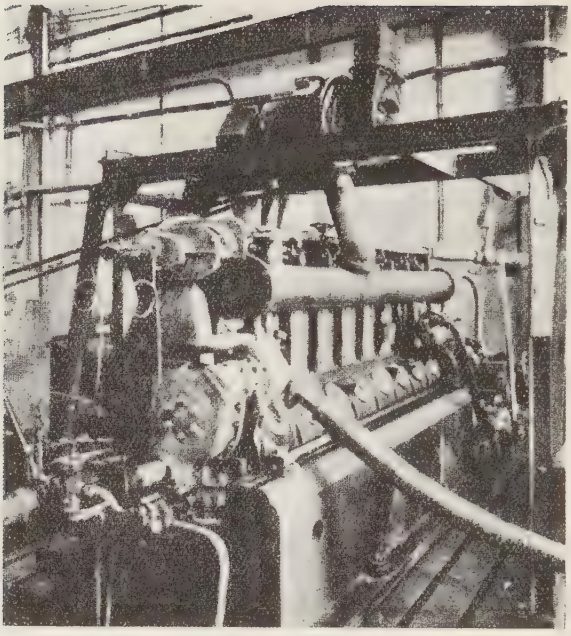


Fig. 17. — M.A.N.-S.G.C.M. 280/350-H.P. diesel engine supercharged by Rateau turbo-blower (for P.L.M. Somua railcar). Installed on S.G.C.M. test bed.

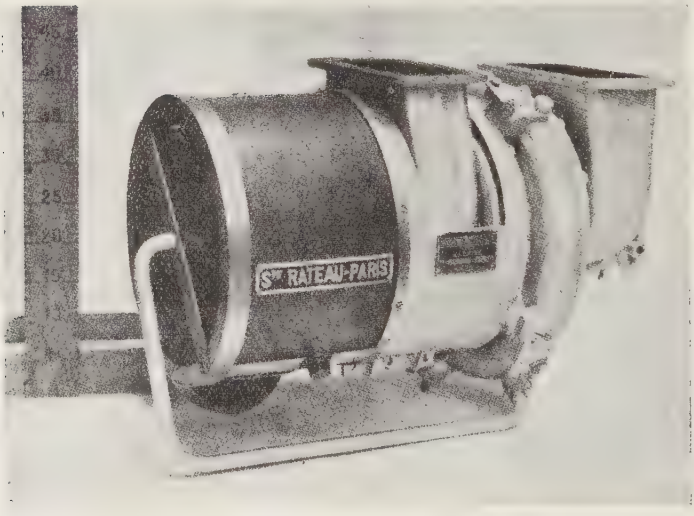


Fig. 18. — T.A.R. Franco-Belge (1937) diesel-electric set, Nord Railway. — Rateau supercharging turbo-blower for Maybach 670 56 410/550-H.P. engine at 1 400 r.p.m. Three-quarter view, turbine side.

turbo-groups, with particulars of their uses.

* * *

Supercharging by turbo-blower, in spite of the difficulties to which it gives rise, in theory as much as in practical application, is now in current use for diesel engines and four-stroke petrol engines.

The power/weight ratio is increased and the overall dimensions per installed H.P. are reduced. Therefore the serious difficulties the constructor is up against, when it is desired to increase the power of an engine installed on a railcar or diesel locomotive, are to a large degree offset.

Experience with this device, not very great in the U. S. A., but fairly extensive in France, and even more so in Germany, may be called conclusive : The working of supercharged engines is at least as reliable as that of normal engines, and their installation is easier. From the financial point of view, the supercharged engine comes off best.

Supercharging of two-stroke engines appears to be a question for future development. If, however, the results which appear possible in theory are achieved, great developments may be expected in engines of this type.

[625. 244 (.73)]

American refrigerator wagons (*

by Reichsbahnrat Helmut BAUR, WVV, Berlin

(From *Verkehrstechnische Woche.*)

Recently experts have decided that it is well to pack the air space, so frequently used as a heat insulator, with some heat insulating material, seeing that the utility of an air space is very questionable, owing to the difficulty of keeping it properly airtight and therefore of maintaining the air in a state of rest, which alone constitutes heat insulation. The airtightness of the doors is ensured at the tops, at the verticals and the joints of the two leaves by the usual elastic strip pieces, formed of hairfelt and waterproof canvas cloth kept tight. The door being closed, a round rubber packing piece, in waterproof covering, presses against a turn-up edge on the floor, by the door tread, while a second similar piece is attached to the lower edge of the turn-up, and another to the cross piece of the door framing. As the door floor treads wear considerably they are made in the latest wagons of an artificial resin product (bakelite).

All steel pieces are hot galvanised. The floor grills are indeed of wood but have recently also been made of steel. The wooden parts of the interior of a wagon are impregnated with rubber varnish, an excellent protection against moisture; outside the wagons are painted a light orange colour, of a shade which reflects the solar rays well without showing the dirt so readily as white. A glossy finish is adopted in an effort to prevent dirt from depositing itself.

The *tare* of the all-steel refrigerator wagon, designed, as the standard wooden one, for a load of 36 t. (35.4 Engl. tons) is 24 t. (23.6 Engl. tons), giving a saving over the latter of 26 — 24 = 2 t., or 7.7 %. The relations between the weights are :

Tare per ton of normal load . . . . $\frac{24 \text{ t.}}{36 \text{ t.}} = 0.666$ ton.

(*) Concluded from May 1940 number, p. 183.

Tare per m^3 of useful load space	$\frac{24 \text{ t.}}{68 \text{ m}^3} = 0.353 \text{ t./m}^3 = 0.0098$ *Engl. ton/cu. ft.*
Tare per m^2 of floor	$\frac{24 \text{ t.}}{39.5 \text{ m}^2} = 0.81 \text{ t./m}^2 = 0.074$ *Engl. ton/sq. ft.*
Tare per lineal metre of overall length of body	$\frac{24 \text{ t.}}{12.25 \text{ m.}} = 1.96 \text{ t./m.} = 0.588$ *Engl. ton/foot.*
Weight of the body	24 t. — 6 t. (bogies) = 18 t. *(17.7 Engl. tons)*
Weight of the body per lineal metre of overall length of body	$\frac{18 \text{ t.}}{12.25 \text{ m.}} = 1.47 \text{ t./m.} = 0.44$ *Engl. ton/foot.*

Tests have been made with stationary wagons of this new type with the object of arriving at the *co-efficient of heat transmission* of the whole wagon, inclusive of the effect of leaks, and it has been found to be 0.4 kcal/m^2 h. ° C. (0.82 B.T.U. per sq. ft. per hour per degree F.). However, to appreciate the significance of this figure the method of testing must be taken into consideration. The wagons tested were placed under a screen protecting them against the rays of the sun, but where they were exposed to fluctuations of surrounding temperature, varying between 16° and 26° C. (60.8 and 78.8 ° F.). The internal and external temperatures were measured by means of electric resistance thermometers. The ice chambers were fitted with pieces of ice about the size of a fist. The internal temperature once brought to the working figure, the distance from the upper surface of the ice to the edges of the feed manholes, after prodding the ice with a stick so as to fill up any recesses due to melting, was measured. This operation was repeated at the end of 24 hours and the difference between the distances from the surface of the ice mass to the manholes served as a basis for calculating the weight of ice melted and, from that, the quantity of heat Q which had penetrated into the wagon. Knowing the interval of time Z between the two operations, the external and internal temperatures as measured, *ta* and *ti*, and the mean surface of the wagon, F, the co-efficient of heat transmission can be calculated from

$$k = \frac{Q}{F \cdot Z \ (ta - ti)} \text{ kcal./m}^2 \cdot \text{°C}$$

This method must, it is true, be regarded as somewhat rough and approximate : In the first place it was impossible to get a constant external working temperature, absolutely necessary for tests of this kind; added to that, appreciable errors can enter into the measurement of the distance from the surface of the ice to the manhole, according to whether the ice mass is more or less packed tight beforehand. It can scarcely be conceded that the co-efficient of heat transmission of the American wagons is inferior to that of the new German ones, which have a still thicker heat insulating layer. A co-efficient of 0.47 (0.96 B.T.U./sq. ft./hour/°F.) has been got with the latter by heating the test vehicle to a temperature of 45° C. (113° F.), that of the test room itself being maintained constant. In this way the quantity of heat transmitted can be accurately determined from the energy absorbed by the electric heater elements.

Welding has been applied on a much larger scale by the *Pullman Company* in a design of refrigerator wagon built about the same period. The various parts, such as central longitudinals, cross bearers, and side supports, are welded, chiefly by the electric arc process, only a few parts being connected by rivets. The outer sheet and roof panels are secured to the body framing

by spot welding. These sheet plates are only 1.2 mm. (0.047 in.) thick, and to increase their stiffness they have 6 deep horizontal corrugations along the walls and 3 transverse ones in each roof section piece. The supporting parts of the underframe and the body frame as well as the steel panelling, are in special steel of high mechanical resistance, offering also a great resistance to corrosion [« Cor-Ten »-steel, tensile strength 60 kgr./mm² (38.1 tons/sq. in.), copper content 0.3 to 0.5 %]. The interior lining is in wood. The heat insulating material is again kapok fibre, which is particularly suitable for light weight construction, owing to its very low specific weight. This wagon, capable of loading 36 tons, weighs 20 tons, 16 tons being for the body, representing a saving with respect to the standard design of 36 — 30 = 6 tons, or 23 %.

The relative values are as follows :

Tare per ton of normal load . . . . $\frac{20 \text{ t.}}{36 \text{ t.}} = 0.555$ ton.

Tare per m³ of useful load space . . . $\frac{20 \text{ t.}}{68 \text{ m}^3} = 0.294$ t./m³ = *0.082 Engl. ton/cu. ft.*

Tare per m² of floor surface . . . . $\frac{20 \text{ t.}}{29.5 \text{ m}^2} = 0.68$ t./m² = *0.063 Engl. ton/sq. ft.*

Tare per lineal metre of overall length of body . . . . . $\frac{20 \text{ t.}}{12.25 \text{ m.}} = 1.63$ t./m. = *0.49 Engl. ton/ft.*

Weight of the body per lineal metre of overall length of body . . . . . $\frac{14 \text{ t.}}{12.25 \text{ m.}} = 1.14$ t./m. = *0.34 Engl. ton/ft.*

A special method of construction is met with in the *Pennsylvania Railroad*'s refrigerator wagons, intended for the rapid conveyance of perishable foodstuffs in passenger trains and in consequence, equipped with passenger carriage bogies. They are all-steel vehicles, the inner covering of the roof, walls and floor being of that material, and riveted, assembly being effected as follows : The Celotex heat insulating material is first spread on the lower steel covering above the underframe. The upper covering, formed complete of welded steel panel plates is then placed thereon, and the inner wall panelling, stiffened by means of pressed section metal verticals, is riveted to its turned up edges. The roof panelling is then placed on this, likewise stiffened by the U section pieces in the heat insulation space. The inner metal panelling being complete, the heat insulating material, of kapok matting, is placed around it, as seen in Fig. 7. Finally the outer panelling and roofing are mounted, with their posts and ribs staggered with respect to those of the inner panelling. The rivets are inserted after treating the insides of the holes with asphalt; this appears to ensure a

Fig. 7. — All-steel refrigerator wagon, Pennsylvania Railroad. Interior shell blanketed with insulation, before application of outer shell.

good tightness at the joints. The tightness of the joints in the assembled side and end walls is obtained by letting their ends overlap after being bent at 45° and in joining them together by enveloping the two edges by a strip of folded sheet plate and riveting the whole together. The governing idea in this form of construction, proceeding from the inside to the outside of the vehicle, is to avoid, by completely separating the inner and the outer panellings, all heat conducting bridge between them. The walls of the ice chambers are removable so that they may serve as a load space when the wagon is running without ice.

These wagons have been built since the end of the 1920-1930 decade : the railway company considers that they have given satisfaction and there are now about 550 in service. As a result of the form of construction adopted, their tare is very high, amounting to 43 t. (42.3 Engl. tons) for a load carried of 36 t. (35.4 Engl. tons). The total capacity of the ice chambers is 6.8 t. (6.7 Engl. tons).

A comparison of the proportional tare weights of the new American and German (3) light weight refrigerator wagons, which we give in Table 2 below, is of special interest.

The tare per ton of normal load (third line in Table 2) does not afford an exact basis for a comparison, seeing that the low load tonnage of the German

TABLE 2.

—	American refrigerator wagons.		German refrigerator wagon, series 6000; steel, welded; outer and inner shells, wood.
	A. A. R. wagon, steel mostly riveted; outer shell, steel; inner, wood.	Pullman wagon, steel, mostly welded. Outer shell, steel sheet; inner, wood.	
Tare, metric *(Engl.)* tons . . .	24 t. *(23.6 tons)*	20 t. *(19.7 tons)*	14.1 t. *(13.9 tons)*
Load carried, metric *(Engl.)* tons.	36 t. *(35.4 tons)*	36 t. *(35.4 tons)*	15.0 t. *(14.75 tons)*
Pare per ton of load	*0.666 ton*	*0.555 ton*	*0.94 ton*
Tare per cubic metre of load space	0.353 t. *(0.0098 ton/cu. ft.)*	0.294 t. *(0.0082 ton/sq. ft.)*	$\frac{14.1 \text{ t.}}{61 \text{ m}^3} = 0.23$ t. *(0.0064 ton/cu. ft.)*
Tare per square metre of floor surface	0.81 t. *(0.074 ton/sq. ft.)*	0.68 t. *(0.063 ton/sq. ft.)*	$\frac{14.1 \text{ t.}}{25 \text{ m}^2} = 0.56$ t. *(0.051 ton/sq. ft.)*
Tare per lineal metre of the overall body length	1.96 t. *(0.588 ton/ft.)*	1.63 t. *(0.49 ton/ft.)*	$\frac{14.1 \text{ t.}}{10.38 \text{ m.}} = 1.36$ t. *(0.41 ton/ft.)*
Weight of body, metric *(Engl.)* tons	18 t. *(17.7 tons)*	14 t. *(13.8 tons)*	11.6 t. *(11.4 tons)*
Weight of body per lineal metre of overall body length	1.47 t. *(0.44 ton/ft.)*	1.14 t. *(0.342 ton/ft.)*	$\frac{11.6 \text{ t.}}{10.38 \text{ m.}} = 1.12$ t. *(0.336 ton/ft.)*

(3) See *Organ für die Fortschritte des Eisenbahnwesens*, 1937, No. 6 : TASCHINGER. Neue Reichsbahnkühlwagen für 90 km./h. Geschwindigkeit (New German State Railway refrigerator wagons for speeds up to 56 m.p.h.).

wagons reflects the much lower permissible axle load. In addition a certain minimum weight is necessary for a wagon, to render it capable of absorbing the stresses produced during the journey or when being shunted. The greater the tonnage the less the part played in it by the minimum weight per ton of normal load. The weight brought into play does not increase in the same proportion as the load tonnage. Similarly lines 4 (t./m³), 5 (t./m²) and 6 (t./m.) enable no true comparison to be made owing to the constructional differences between the American and the German wagons; the latter are 4-wheeled while the former are 8-wheeled.

The most satisfactory basis for appreciating the quality of lightweight construction attained is afforded by line 8; this contains the weight of the body alone, expressed per lineal metre (and per foot) of the body length. This shows that the new German refrigerator wagon design is not inferior to the American one from the point of view of lightweight construction.

In refrigerator wagons constructed recently tests have been made, with the object of *improving the air circulation,* with air ducts along the inner roof and centrifugal ventilators, wind driven by rotors placed on top of the roof and drawing out the ascending warm air below the roof, sending it back through the ducts to the ice chambers. This air circulation equipment is thus similar, in principle, to that used in the new German wagons. Trials have also been made with air circulation *without* the ducts referred to, two rotor driven ventilator fans being merely set side by side on the transverse centre line of the roof. The double winged rotors on top of the latter were 255 mm. (10 in.) high and 380 mm. (15 in.) diameter, the four winged fans placed under the inner roof of the load space were 735 mm. (29 in.) diameter. These air circulation equipments have not as yet made headway in America, though trials with them appear to be continuing. Instead, an endeavour is rather made to cool the load in a uniform manner before the journey commences, either with the aid of special fixed equipment serving to blow the cold air through the loaded wagon, or by using ventilating fans placed in the upper ice chamber openings to circulate the air through the charged chambers and the load of goods.

Some few wagons have also been built in which ice chambers were hung from the inner roof. This has the advantage of affording a greater uniformity in the cold air supply reaching the load throughout the length of the wagon. The disadvantages are having to have numerous ice containers along the roof and the dripping of water on the load. This so much outweighed the advantages that the arrangement was not adopted. The placing of ice containers along the side walls proved just as unsatisfactory.

To ensure the charge in an ice chamber retaining its effectiveness for a longer interval salt containers have recently been developed, which are hung in the upper part of the chambers after these have been charged with ice. As soon as this has been melted away down to a certain level, the cooling ice surface and the effect on the air having diminished in proportion, the salt container tips up and empties its contents on the remaining quantity of ice, thereby forming a refrigerating mixture, the temperature of which, falling below 0°, compensates the loss of effect from the ice alone.

(b) *Refrigerator wagons using « dry ice ».*

Ten years ago extended investigations were made in America into the use of « dry » ice — or carbonic acid snow — compressed into blocks. It was found, however, that for non-frozen perishable foodstuffs such dry ice was unable to compete with ordinary ice from water, given the difference of price between the two sorts. Water ice costs $ 4 per short

ton (2 000 lb.) or about 0.25 cent per pound, while dry ice costs 1 to 1 1/2 cents according to the quantity purchased annually, that is to say 4 to 6 times the price of ordinary ice. The use of dry ice can only be considered therefore for frozen foodstuffs. The heat insulation of the normal type of refrigerator wagon, however, gives rise to too great a consumption of dry ice to make it economical to use the latter. Better insulated wagons are required and there are only a few of them. Under these circumstances perishable foodstuffs are kept cold in railway wagons with the aid of ordinary ice with a strong proportion of salt added, or with brine. The use of dry ice is essentially confined to the consignments of a few wholesale meat shippers, whose refrigerator wagons are fitted in the upper part of the side walls, near the doors, with heat insulated reservoirs of dry ice serving to complete the ice charge in very warm weather and with the aid of which the wagons appear able to complete their journey without having to have any ordinary ice added. The two reservoirs, placed diagonally in the wagon, each hold 140 kgr. (300 lb.) of dry ice.

These American experiments have, however, demonstrated like the German investigations (4), that the addition of dry ice to the extent of 10 to 20 % of the ordinary ice by weight — an amount which would appear to be justified from the cost point of view — exercised no appreciable influence on the temperature of the load and, in addition, led to no saving in ordinary ice. The question of the effect of carbonic acid gas on the various kinds of perishable foodstuffs remains, however, unaffected; as yet it has not been sufficiently elucidated to further the practical application of such gas to loads in course of transport.

The 36-ton wagons, constructed for dry ice refrigeration, have a heat insulation of 178 mm. (7 in.) while the usual thickness is about 75 mm. (3 in.). In addition, their airtightness has been increased by an outer steel panelling. The gastight dry ice troughs, ribbed externally to promote the transmission of heat, are suspended from the roof of the customary compartments isolated by transversal partitions, at the ends of the wagon. They are surrounded by strongly heat insulating coverings (150 mm. = 6 in. of cork) the passage of air through which is regulated by flap valves controlled in turn by thermostats, the action of which depends on the internal temperature. The gaseous carbonic acid can be directed at will either towards the interior of the wagon, in order to maintain there a concentration of CO^2 beneficial to the load, or into the atmosphere. The total capacity of the ice containers is 1 400 kgr. (3 000 lb.) of dry ice. It appears that with wagons of this type temperatures down to — 27° C. (— 16.6° F.) have been obtained and that the variation between the temperature decided on for the thermostat and that actually resulting from the action of the regulating mechanism never exceeded the limits of — 1.5 and + 2.5 %.

(c) *Wagons containing a refrigerator.*

The refrigerator, both on the absorption and the condensation principle, has been used to keep foodstuffs cold in railway wagons. The production of cold is of 6 000 to 9 000 kcal./h. (24 000 to 36 000 B.T.U./h.). There are, however, only some 100 to 200 such wagons, an insignificant number in proportion to the total stock of American refrigerator wagons. The following advantages are claimed for the wagon containing a refrigerating apparatus :

(1) No loss of time due to the initial fill-

(4) See *Zeitung des Vereins Mitteleuropäischer Eisenbahnverwaltungen*, 1936, No. 8 : TASCHINGER. Kühlversuchsfahrten der Deutschen Reichsbahn-Gesellschaft im Jahre 1935 (Refrigerator wagon test trips made by the German State Railways in 1935).

ing up of ice chambers and ice renewals;

(2) Exact regulation of load temperature;

(3) Low temperature possible for frozen foodstuffs;

(4) No dripping of saline water from ice chambers to which salt has been added, or brine dripping from leaky discharge valves of brine reservoirs, hence no corrosion of permanent way and bridges.

The fact that the number of wagons carrying a refrigerator does not exceed the number above quoted, points to their having no superiority over the ice and brine cooling methods. Particulars obtained personally confirm this. Among the disadvantages of such vehicles, compared with the usual arrangements, are quoted the high first costs and maintenance charges, the lower cold production efficiency, which has a particularly unfavourable effect when it is a question of chilling a warm load, the difficulty of maintaining the mechanical apparatus in working conditions amidst the rough movements of goods wagons, as well as the need for a trained maintenance staff. The refrigerator machine wagons are let to shippers by the builders.

Wagon with absorption type refrigerator.

The principle of the absorption type of refrigerator apparatus is shown on Fig. 8; Fig. 9 shows how it is mounted in a wagon. The evaporator coil pipes, in which the freezing mixture (sulphurous acid) is kept by a float valve at a predetermined level, are suspended from the roof, above the channels serving to catch water condensed from the air. The freezing mixture evaporates in the coils and extracts from the ambient air and the load the heat necessary for that process, hence chilling the air and the goods. The gaseous freezing mixture is absorbed by the finely porous silica gel of the absorber, which is placed in a special compartment at the end of the wagon. By means of a timing device, check valves actuated by the pressure of the heating gas of the absorber (see later), interrupt the communication between the absorber and the evaporator and connect it to a condenser, the coil pipes of which are placed on the wagon roof under a cover open at the sides. At the same time a burner using compressed gas (fed in the recent types of

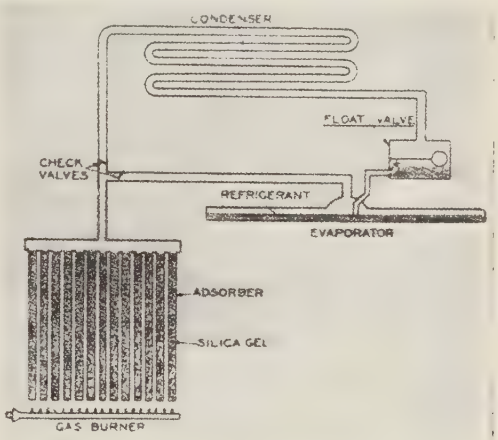


Fig. 8. — Diagram of absorption type refrigerator.

equipment by propane gas) is set in action under the absorber while suction ventilators begin acting above it; the burner heats the absorber and drives out the absorbed freezing material. The latter collects in the condenser and flows thence towards a collector from which it recommences its circuit by passing through the float valve before mentioned. To ensure the continuity of the process the absorber is divided into two parts, so that one half can continually absorb the freezing mixture while this is in turn being driven out of the other half. A thermostat located in the centre of the wagon under the roof opens the gas admission valve on the burner as soon as the ambient temperature falls

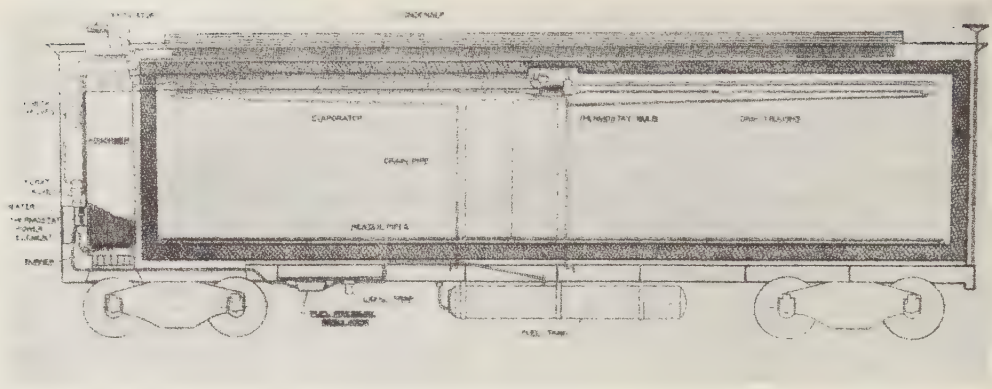
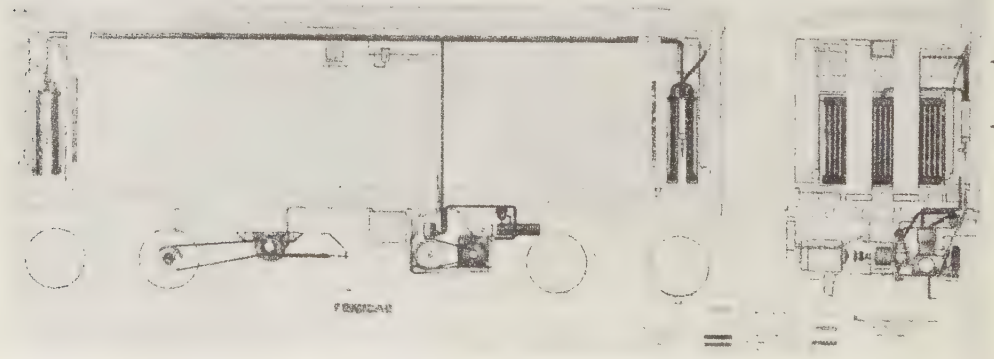


Fig. 9. — Wagon fitted with absorption type refrigerator.

below the predetermined value and closes it when the right figure is once more attained. A continuously burning pilot flame lights the burner. The compressed gas reservoir is suspended, with its pressure regulator, under the wagon. Another advantage claimed for wagons fitted with absorption refrigerators is that the space taken up by the apparatus is only about that required for *one* ice chamber, leaving the other end of the wagon free for goods. About 85 such wagons have been built and are worked in service by the Safety Refrigeration Inc., of New York.

Wagons with condensation type refrigerator.

Fig. 10 shows a wagon with a condensation type of refrigerator. The latter with its electric motor, comprising a direct and alternating current unit, is suspended in a box under the vehicle. When the wagon is in motion, a dynamo



Axle driven dynamo. Refrigerator with driving electric motor.

Fig. 10. — Wagon with condensation type refrigerator.

driven by one of the axles provides current to the d.c. unit of the refrigerator; for the pre-chilling of the wagon when stationary, the a.c. unit is supplied with power from the town mains through a plug and cable connection. The voltage regulators for the dynamo, cutouts and fuses are grouped in a case fixed to the wagon underframe. The evaporater is in two halves, fixed at the ends of the wagon in place of the ice chambers. Parallel to them the freezing mixture traverses the brine troughs, which serve as storage reservoirs for cold to meet stoppages en route. Air is drawn in under the roof at each end of the vehicle by blowers and, to cool it, sent thence through evaporator coils and brine troughs, eventually reaching the underside of the load via the floor grills. The condenser and freezing mixture reservoir are placed under the wagon. The thermostatic control operates as follows : One thermostat diverts the freezing mixture to the evaporator coils in the brine troughs as soon as the desired temperature in the wagon is obtained. A second thermostat, set for a slightly lower temperature, puts the refrigerating apparatus out of action when the brine troughs are fully charged and commence to make the temperature in the wagon drop still lower. About 50 of this class of wagon have been built by the North American Car Co., Chicago, which also works them in service.

Trials have also been made, but on a very small scale, with diesel engine operation for the refrigerator; the power developed by the engine in a standard wagon equipment was 8 h.p.

3. Heating of heat-insulated wagons.

During the winter refrigerator wagons are often warmed to prevent the actual freezing of fruits and vegetables. Various sources of heat are employed. The simplest arrangement consists of portable charcoal stoves placed in the ice chambers. The air rises in these chambers, spreads out under the wagon roof, falls as it cools and, yielding its heat to the load, is again drawn into the chambers under the action of the ascending heated air. Instead of coke stoves, paraffin oil and alcohol heaters are frequently used, as well as automatic oil or propane heaters, controlled by thermostats, in the wagons carrying refrigerating apparatus — sometimes also in the ordinary type of refrigerator wagon. Propane gas heating warms the contents, composed of diethylene — glycol, of a network of pipes placed beneath the floor gratings. All these systems of heating have the advantage of being independent of any external source of heat : steam furnished by the locomotive or some fixed heating installation. There are also wagons fitted with heating equipment thermostatically controlled. In addition to equipments having heating pipes and natural air circulation there has also been a proposal to use a small steam turbine driving an air circulation blower, the air stream from which is warmed by the exhaust steam from the turbine in a radiator. This is therefore a forced air circulation system. In order to make steam heated wagons independent — at least for a certain time — supplementary heat accumulators have been fitted in them, formed of porous terracotta, which are heated up during the time the steam is being supplied and gradually deliver up their heat when the vehicles are stationary and unprovided with steam. Such accumulators have to be capable of keeping the load in a wagon above freezing point for 24 hours with an outside temperature of — 18° F.

4. Special refrigerator wagons for the conveyance of milk.

The numbers of inhabitants in the large American cities are such as to necessitate the supply of very large quantities of milk, larger than the amounts met with in Central Europe, and

in addition the consumption of milk per head is considerably higher in America than in Germany. The average figure for 1935 was 0.43 kgr. (0.95 lb.) per head per day in America and 0.24 kgr. (0.53 lb.) in Germany. The great size of the large American cities leads to their milk producing districts extending over a large surrounding area. The big dairy supply firms concentrate large quantities of milk on the collecting centres where it is in consequence necessary to have large enough containers available for transporting it further. It became no longer possible to use the usual steel churns for a traffic of this size, first of all for reasons of space and weight, and lastly because their handling entails too high a cost on wages and time. This led to the construction of large capacity milk tank wagons. Fig. 11 illustrates the interior of one of these. It contains two reservoirs having a total capacity of 22 600 litres (5 000 Br. gall.). These tanks are made in one piece without a seam; the forward end alone is riveted or welded to the body. The inside is lined with glass, the effect of which is to prevent the contents causing any corrosion of the tank and to keep the quality of the milk unharmed. In addition the tanks can be cleaned, fully and quickly, with facility. Recently the tanks have been made of stainless steel, rendering the glass lining unnecessary. The floor, inner roof and walls of the new wagons are also covered in stainless steel panelling; this material is likewise used to cover the heat insulating material 50 to 100 mm. (2 to 4 in.) thick, around the tank, the entire internal fitting up of the vehicle thus answering to the strictest hygienic requirements. Fig. 12 shows the chief accessory fittings on the tank. On the front face is seen, on the left, an electric motor, with reduction gear, which works a churning screw in the tank to prevent the cream from separating. Immediately above the lowest point of the inside of the tank (the latter being arranged on a slope from back to front) the discharge piping is attached. Quick and complete emptying is ensured by a

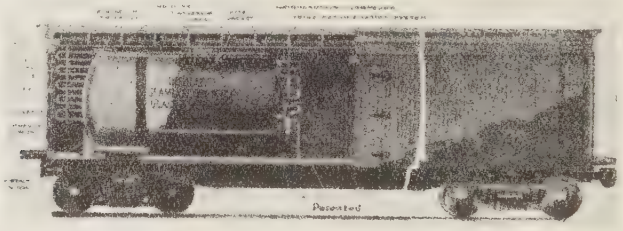


Fig. 11. — Refrigerator milk tank wagon.

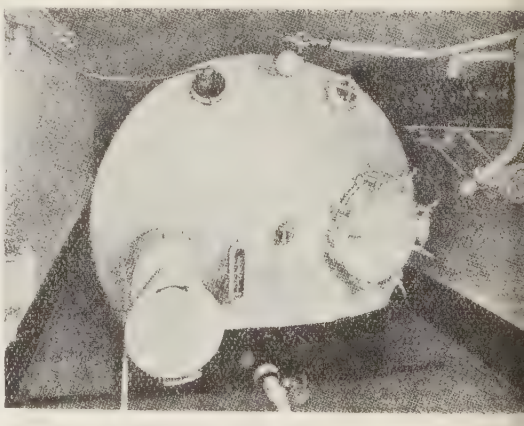


Fig. 12. — Inside view of milk tank wagon.

blower device, driven by an electric motor and placed on a bracket fixed to the wall on the right, which creates an air pressure above the contents of the tank. The air drawn into the blower is filtered. A thermometer, a pressure gauge, an inspection window and inspection lamp complete the equipment. The electric motors take their power from an axle driven dynamo and an accumulator battery under the wagon, which also provides current for lighting. These milk tank wagons frequently have no special refrigerating equipment, the mass of milk cooled to + 1° C. (34° F.) forming a cold accumulator of such a size that its temperature does not appreciably rise during the journey. Wagons intended to go exceptionally long distances have ice or brine refrigeration. The walls, floor and roofing are heat insulated in the usual manner. The doors have hollow rubber joint packing pieces which, when the door is closed, press against flat rubber strips in the door framing.

[621. 431.72 & 656. 222.1]

Railcar acceleration with mechanical transmission

An examination of the problems involved,

By J. L. KOFFMANN.

(*Diesel Railway Traction*, Supplement to *The Railway Gazette.*)

Until a few years ago mechanical transmission was regarded as suitable only for use with engines up to 150 B.H.P.; its present limit is about three times as high, and more care must be devoted to the problem of accelerating high-power cars, with a transmission having only a limited number of gears.

During a start the passengers are affected not by the rate of acceleration dV/dt, but by its first derivative, *i.e.*, by the second derivative of speed, the shock $S = d^2V/dt^2$. During rapid acceleration the accelerating force, together with the force of gravity, forms a resultant applied at a certain angle upon the passengers. A rate of acceleration of 3.3 ft. per sec. per sec. will result in an apparent increase in weight of about one per cent., and the corresponding angle will be about 6 deg., this being the angle which a standing passenger must assume in order to counteract the tendency to fall over. The adjustment to such a position is effected without noticing it as long as the rate of change of acceleration is effected gradually, being troublesome only when this value is high; for example, rates of change of about 1.5 ft. per sec. per sec. are felt as unpleasant. The stress upon passengers due to acceleration is expressed by the equation

$$S_1 = S\left(\frac{d^2V_1}{dt^2} - \frac{d^2V_2}{dt^2}\right)$$

where V_1 and V_2 are the speeds at the beginning and end of a definite interval.

From this it is obvious that the comfort of the passengers can be enhanced by ensuring a gradual alteration in the rate of acceleration, which would require the accelerating force to be increased gradually from zero at the start to a maximum at a point about halfway to the maximum speed, and then by gradually decreasing the rate of change to zero as the speed aproaches its maximum. But this is neither possible nor desirable, as to attain a certain speed

on these principles the maximum force required must have twice the value of a constant acceleration force, this resulting in a poor utilisation of the power available, and therefore a compromise must be sought.

Acceleration progress.

At starting the rate of acceleration rises rapidly to its maximum as soon as the clutch is let in. While changing gear, an operation requiring 2 to 3 sec., the tractive effort drops to zero and the speed decreases. As soon as the next gear is engaged and the clutch applied, the car gains speed, the rate of acceleration decreasing as the speed increases. This interruption of the tractive effort and the consequent jerks and loss of time due to gear-changing are at present one of the main disadvantages of mechanical transmission. Four- and five-speed transmissions are widely adopted even for moderate top speeds, but some operators advocate up to eight speeds in order to obtain more even, yet rapid, acceleration. But it seems natural that the ultimate development should tend towards a sustained drive, such as given by the Freeborn box, and from there to an infinitely-variable mechanical drive. Another transmission for which sustained drive is claimed is that just developed by Ansaldo, in Italy. This gear is of an epicyclic type, and is engaged through the medium of mercury-filled rotary cylinders coupled to the planet wheel sets.

As an example of the conditions encountered, consider a twin-engine bogie railcar with rounded front, weighing 40 tons when fully laden, and with power furnished by two Saurer BXD engines fitted with Büchi pressure-chargers to give a maximum individual output of 220 B.H.P. at 1 500 r.p.m. The tractive effort curves are plotted on the assumption that the overall efficiency of the power plant is 85 per cent., and the train resistance curves are calculated to the formula of the German State Railways for a standard-gauge bogie car with curved front (*),

$$R = 5.5\ W + 0.054A\ (0.16V)^2$$

where R is the total resistance in lb., W the car weight in tons, V the speed in m.p.h., and A the frontal area in sq. ft.

Tractive effort curves for both four- and eight-speed transmissions are shown in Figs. 1 and 2. The coefficient of friction between wheels and dry rails may be taken as $f = \frac{565}{26 + V} + 11.6$ (†), this value being reduced by about 30 per cent. with wet rails. The wheels may spin in first and second gear with the multi-speed transmission, and there is also a possibility of spinning on wet rails in the first gear of the four-speed

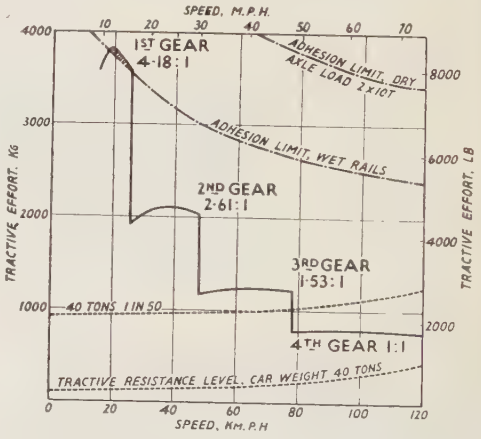


Fig. 1. — Speed-tractive effort curves of 440-B.H.P. twin-engined diesel-mechanical railcar with four-speed gearbox and transmission.

(*) JUDTMANN : « Motorzugförderung auf Schienen » : Vienna, 1938, p. 18.

(†) KOTHER : « Fahrzeitermittlung und Bestimmung der Beanspruchung der Fahrmotoren elektrischer Triebfahrzeuge. » *Elektrische Bahnen*, Dec. 1937, p. 297.

unit. A higher tractive effort is ensured at starting with the eight-speed gear, but although on a grade of 1 in 50 a speed of 49 m.p.h. can be maintained with the four-speed gear, only about 44 m.p.h. can be attained with the eight-speed transmission.

Notwithstanding the fact that higher rates of acceleration are ensured in the top gear-steps with the multi-speed transmission, the advantages gained are more than offset by loss of time required for gear-changing. The loss in speed as well as the distance covered while gear-changing can be derived from the equation of a movement against a resistance increasing with the square of the speed, the simplified resultant formulæ (**) for the car concerned being :

$$V_1 = \frac{1610WV - 35.32\ (2.5 + g) \times W \times t}{1610W + 0.0132A \times V \times t} \text{ m.p.h.}$$

$$l = \frac{1610WV - 17.66\ (2.5 + g) \times W \times t}{1610W + 0.0066A \times V \times t} \text{ 11.8 ft}$$

where V is the speed in m.p.h. at the beginning and V_1 the speed at the end of each gear-change period, t the time required for gear-changing in sec., g the gradient in per cent., and l the distance covered during gear-change, in ft.

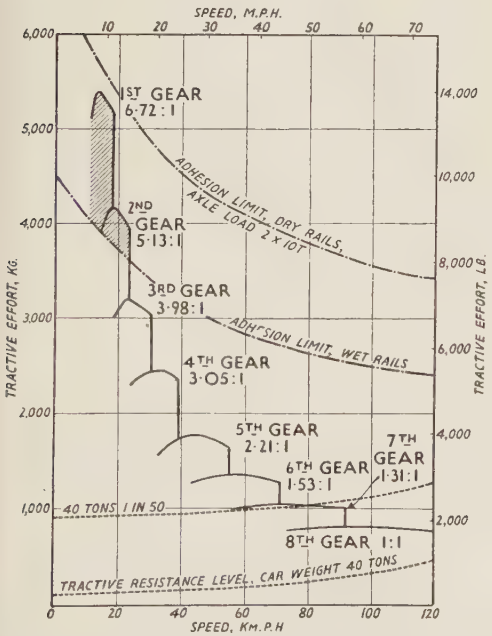


Fig. 2. — Speed-tractive effort curves of 440-B.H.P. diesel-mechanical railcar with eight-speed gearbox.

The performance of the 440-B.H.P. car with a four-speed gearbox along the level and up a gradient of 1 in 50 is shown in Fig. 3. The dotted lines represent the results obtained when using a sustained-drive transmission with the same gear ratios. The performance with an eight-speed gearbox is shown in Fig. 4.

Comparison of performance.

With a normal transmission the advantages obtained in using a sustained-drive arrangement are not great so far as gains in time and distance are concerned, but acceleration is achieved more smoothly, notably when changing from first to second gear. The eight-speed gear, however, in normal circumstances and with the ratios chosen, seems as if it would be of advantage only when arranged as a sustained drive; otherwise the time required for changing through the increased number of gears would result in a marked handicap against rapid acceleration. Some advantage would be gained when starting on gradients, as here the increased number of gears would ensure a better

(**) Opatowski : « La perte de vitesse des automotrices à transmission mécanique au cours du changement de rapport de transmission » (*Chemins de Fer et Tramways*, August/September, 1936).

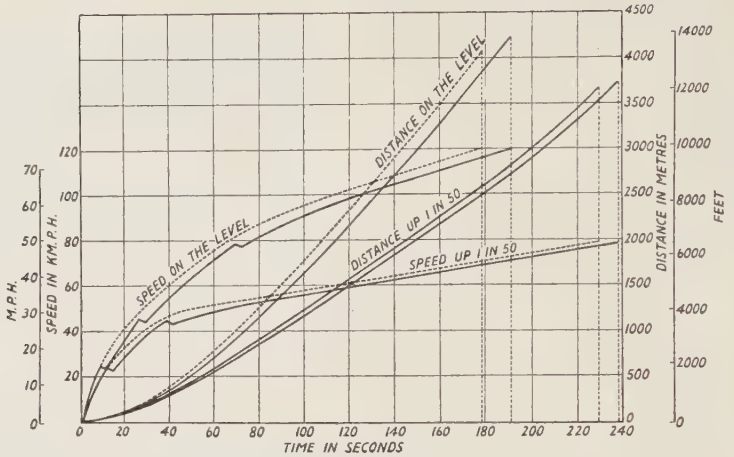


Fig. 3. — Performance of 440-B.H.P. twin-engine diesel-mechanical railcar on the level and up a grade of 1 in 50; four-speed gear box.

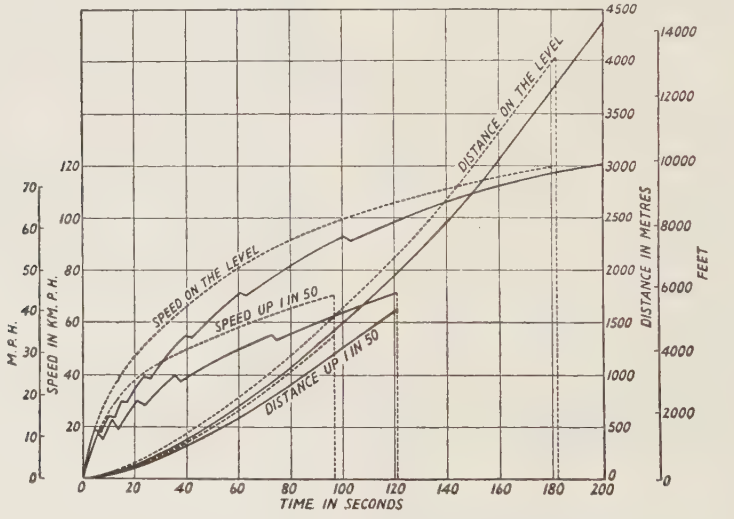


Fig. 4. — Performance of 440-B.H.P. twin-engine diesel-mechanical railcar on the level and up a grade of 1 in 50; eight-speed gearbox. Compare with Fig. 3 and note how acceleration up 1 in 50 grade is better than with a four-speed box, although the fewer-speed box gives rather better results along the level.

distribution of tractive effort between the fourth and seventh gears, a feature which can be of importance when considering that a slight change of slope of the speed-time curve results in a considerable alteration in the time required for acceleration.

From the considerations noted above, it would appear that with medium and high power railcars and multiple-unit

trains the present standard types of four- and five-speed transmissions with interrupted drive can meet the operating requirements. The sustained drive would be of some advantage so far as passenger comfort is concerned and also in permitting a simple fully-automatic control, thus ensuring to mechanical transmission one of the advantages claimed for electric and hydraulic systems. The gains in reducing the time required for acceleration by the use of an eight-speed box are negligible, yet the bulk, weight and both first costs and maintenance expenses might be higher. Should eight or more speeds become desirable for operation over hilly country, the loss of time and speed due to gear-changing would probably justify the adoption of a sustained-drive transmission, provided that a unit suitable for railway requirements could be obtained.

[691 & 693]

Deteriorated concrete. — Causes, detection and methods of repair (*).

(Railway Engineering and Maintenance.)

Concrete is primarily a simple mechanical mixture of sand, stone, cement and water, which « sets up » or hardens under hydrolysis and hydration into a hard, stone-like mass. Owing to the very nature of its ingredients, that is, the sand, stone and products of crystallization, which retain their individual characteristics, all concrete is more or less porous, and the degree of porosity will, in large measure, determine its durability and, consequently, its life.

Causes of deterioration.

It is not the province of this report to consider the effect of structural design on the character of the deterioration of the concrete of which a structure is composed. Deterioration proceeds whether or not proper consideration has been given to the purpose for which the structure was built. A structure of good design is less vulnerable to deterioration, but this great advantage may be vitiated if the concrete is of poor quality.

The primary causes of the deterioration of concrete structures of good design may be ascribed to faulty materials and poor workmanship. Many deteriorated structures were built 25 to 50 years ago when little technical information was available. In spite of age, however, many of these structures are as sound today as when constructed. On the other hand, many recent structures, built under modern specifications, show marked deterioration.

The only tenable explanations of this apparent contradictory behavior of concrete lies in the multiplicity of causes of the deterioration, and combinations of them. Materials, workmanship, temperature alternations, soil, wetness, dryness, exposure and many other causes, each of varying character or magnitude, make it difficult to elim-

(*) Report of Committee (Chairman : S. T. Corey, Assistant Bridge Engineer, C. R. I. & P., Chicago), presented to the 46th Annual Convention of the American Railway Building and Bridge Association (Chicago, 17-19 October 1939).

inate all but two or three and say — « these are the causes ».

We are concerned, of course, with existing structures, practically all of which have no written historical record except quantities and unit costs. If less attention were paid to costs and more to recording the kinds and sources of materials, methods employed in mixing and placing, where water was obtained, soil conditions, temperature alternations, kind of waterproofing and other important data, the cause or causes of deterioration could be determined with accuracy and, what is more important, a repetition of the failure could be avoided in other structures which may be built in the same locality.

We list the more frequent and obvious causes of the deterioration of concrete as follows :

(1) Settlement of foundations; (2) scour; (3) dirty aggregate and poor grading; (4) dirty mixing water, containing oil, alkali or organic matter; (5) excess water or too little water; (6) placing concrete in a manner causing segregation; (7) wrong proportioning of materials; (8) inadequate bond between pours; (9) inadequate protection of the concrete during the setting period; (10) insufficient attention to curing; (11) alkali adjacent to concrete footings; (12) chemical action of water; (13) freezing and thawing; (14) deteriorated or ineffective waterpoofing; (15) corrosion of reinforcing bars; (16) unanticipated stresses, and (17) occluded water and low temperature.

Probably the most disruptive agency in the deterioration of concrete is occluded water, wherever low temperatures prevail during the winter. Everyone knows that water freezes at 32 deg. F., but little thought is given to the fact that ice increases 9 % in volume over that of the water from which it is formed. If the expansion is restrained, the water will remain liquid, but as the temperature is lowered the pressure increases very nearly proportionately. It has been found that if expansion is thus restrained, the pressure rises to 2 000 lb. per sq. in. at 30° F., to 12 000 lb. per sq. in. at 20° F., and to 30 000 lb. per sq. in. at minus 8° F. It is obvious, therefore, that in porous concrete to which water is accessible and where the conditions for more or less restraint exist in the surrounding concrete, the internal pressure rises as the temperature falls below 32° F. When the surrounding concrete is no longer able to withstand the rapidly mounting pressure, the latter is released and the water, changing to ice with explosive force, disrupts large masses of the concrete.

Much good concrete work has been ruined by poorly placed and poorly protected reinforcing bars. Bars will not corrode unless moisture and air are present. Corrosion is accelerated by chemicals such as those present in sea water, smoke, brine and the like. Reinforced concrete members of small dimensions are most seriously affected. Alternate wetting and drying hastens the rusting, which commences at some point where there is insufficient covering of the bars or poor concrete. As rusting proceeds, considerable pressure is generated due to the increased volume of the oxidized iron, which tends to break down the surrounding concrete if it is of poor quality or of small thickness.

In considering the deterioration of concrete and its repair, it is essential to distinguish between damage due to weathering on the exposed surface and that due to water coming through from the back or earth side. Percolating water may remove some of the soluble constituents. All concrete will absorb water, but concrete of fine texture will take up water by capillary action more readily than coarse concrete. This is because the coarser concrete will permit more water to move through it under head.

Good dense concrete is apparently

affected little by wetting and drying and it may even become tighter by the formation and deposition of calcium carbonate from the solution of the soluble calcium hydroxide in the concrete. When the concrete is porous enough to permit the solution to run out of the concrete, damage results from further percolation.

Water moving through a wall must be stopped back of a point where it will freeze. Someone has proposed the slogan, « Keep water out — if it gets in, provide an easy way out ».

Detection of deteriorated concrete.

In many cases the fact that the concrete has deteriorated is obvious even under cursory examination but the primary cause of failure is not always clear. In other cases the deterioration is not apparent and it requires some knowledge and experience to interpret the significance of the symptoms noted during an examination. These symptoms are raveling, cracking, deposits, the popping or cracking of aggregates, color, texture, and the hardness and ring of the concrete, bad condition of the surface, deterioration due to structural defects, drainage, joints, exposed reinforcing bars, surface spalls, wear due to ice and debris, deterioration by water of high chemical content, and others.

A proper diagnosis is imperative for successful treatment. Primarily it must be determined whether the concrete materials are at fault. Many of the symptoms indicated above are traceable to poor aggregate, but much good material has been rendered of little value by poor workmanship. A favorable time to make an examination is after rains while drains are still active but after some drying, or where rains are followed by freezing weather or during a thaw. If the actual conditions are not apparent from a superficial examination, it may be necessary to hack away a small piece of concrete with a sharp tool. Sounding with a hammer will often disclose internal defects. If the concrete rings well, sound concrete may reasonably be indicated; if a hollow sound is produced, loose concrete may be suspected; if a dull sound is heard, dead material is very likely present.

Repair of deteriorated concrete.

General good practice has not been developed for repairing deteriorated concrete. This is shown by many crude attempts at repair. These failures are due largely to a lack of understanding of the proper methods and to inherent difficulties which may be met in certain cases. Many concrete walls and other structures show surface defects which, if neglected, may result in serious damage if not repaired. Such deterioration has been halted and, in many instances, entirely overcome by various surface treatments. Asphalt and cement paints have been found useful, but as a class have a rather limited field and a relatively short life and must be renewed at frequent intervals. Oil paints often saponify and surfaces coated with them must be repainted occasionally. Of the oil paints, a tung oil is recommended as a primer. Another sometimes used has a phenolic resin base for a primer coat, and straight linseed oil has been found, in certain cases, to be effective as a finishing coat.

Railings have been repaired by the application of a hot coat of 1-to-1 turpentine and raw linseed oil, followed by subsequent coats of hot oil until the concrete is saturated. A final coat of grey lead and oil paint was applied to give a satisfactory appearance. Other types of surface treatments consist of numerous mixtures of iron treated with sal ammoniac, or of emulsions of asphalt. Transparent waterproofings, consisting of various materials dissolved in volatile solvents are of little value.

Considerable difference of opinion exists as to the effectiveness of the so-called « iron treatment ». Finely-divided

iron and sal ammoniac are applied to the wet surface of the concrete to be repaired, in the form of grout. The iron penetrates the pores and, expanding there upon oxidizing, presumably fills the pores completely. The application is usually repeated several times and is finally followed by a cement and sand wash. Sometimes this treatment has been used merely as a bonding medium before patching or when making an extensive application of new concrete to spalled surfaces. Numerous successful applications of this iron treatment are on record, but there have been many failures as well, the latter due possibly to the selection of the improper method of repair or to inexperienced workmanship.

Various forms of asphalt waterproofing have been used to repair deteriorated concrete surfaces. Asphalt dissolved in a petroleum solvent, commonly known as a « cutback », asphalt emulsions, or pure asphalt heated to the proper consistency, may be used when the conditions warrant. They are applied as paints or are trowelled on. The concrete surface to be waterproofed must be scrupulously cleaned and then primed with asphalt, well thinned, before application. When applied to exposed surfaces, asbestos fibre, sand or mica may be added to reduce volatilization of the essential oils by sunlight and to increase the strength of the film against abrasion.

The priming coat is followed by the application of two or more coats of the waterproofing material, making a film of substantial thickness. If the asphalt coatings are trowelled on, the thickness of each coat will be much greater than when brushed on, and require, therefore, less time to apply. The trowelled coat is a mixture of asphalt and cement or sand, and is of putty consistency. In either case the completed film should be from 1/16 to 1/8 in. thick. Pure asphalts are weak mechanically and should not be used to fill cracks or cavities. Emulsified asphalt may be used, however, if mixed with cement, using about 10 lb. per gallon of emulsion. Additional strength is obtained by adding clean sand to the asphalt and cement mixture. Asphalt coatings are effective if used between the surface to be waterproofed and the source of the moisture. If the surface is under pressure from behind, the effectiveness of this type of waterproofing is greatly reduced.

Cracks frequently appear in thin concrete or plastered walls, thus allowing moisture to penetrate from the outside. These cracks may be closed by grooving, calking and painting if of appreciable width and if not numerous. If they are small in size and large in number, any good cement paint or raw linseed oil can be used successfully. This treatment may have to be repeated several times.

The waterproofing of construction joints and structural cracks, particularly where water pressure is high, is exceedingly difficult. If the concrete is not subject to freezing temperatures and the joints are narrow, they may be calked. The procedure is as follows : First, a drainage system of some kind should be installed to collect and remove the water. The joint or crack should then be channeled and thoroughly cleaned. The channel should be square-cut, approximately 1/2 in. wide by 2 in. deep, and then widened to 1 in. for the first 1 in. of depth. After the sides and bottom of the channel have been thinly primed with cutback asphalt, the 1/2-in. by 1-in. space in the bottom should be calked with oakum and sealed by filling the front space with cement mortar or asphalt and cement mortar. Cement mortar should not be used if there is structural movement.

If the joint or crack is exposed to freezing temperatures, it is imperative to block the water at its source. If water freezes back of the calking the calking will, in all likelihood, be forced out by the expanding ice. In any case,

if it is at all possible, some means should be taken to prevent water from entering the crack or joint at the rear of the wall as moisture will spread into the adjacent concrete by capillary action and saturate it, thus inviting deterioration from subsequent freezing and thawing. Cracks or joints may be protected from moisture entering from the face by grooving and filling with cement mortar, or, if primed, as indicated above, by filling with asphalt-cement roofing mortar, plaster or emulsified asphalt.

It becomes necessary frequently to patch or plaster small areas which have weathered. If these areas are allowed to continue to weather they will result in an unsightly appearance and the safety of the structure, if small, may ultimately be endangered. In such repair, proper preparation of the surface is essential. Means must be taken to overcome the tendency of the new concrete to shrink in setting up and to secure a good bond to the old concrete. Loose and decayed materials must be carefully removed. The edges of the old concrete, outlining the patch, should be cut vertically (preferably under-cut a little) an inch or more, if necessary, and the surface should be cleaned thoroughly of all dust and fine particles by brushing and flushing with clean water. Before applying the new concrete, the area should be soaked with water, but all excess moisture should be removed just previous to the application.

Avoid shrinkage.

To avoid shrinkage of the new concrete, it has been found that mixing the mortar for a certain period before the patch or plaster is applied is effective in most instances. The proper period that the mortar should stand before it is used can be determined experimentally.

To secure adequate bond, successive coats of thick cement grout of one part cement to one part sand should be brushed on the prepared surface of the old concrete, allowing each coat to dry until it is tacky to the touch. After three, four or five coats, as may be found necessary, have been applied, the patch or plaster material should be trowelled on and thoroughly cured by covering it with a damp cloth, kept wet for several days. Each operation should be done with great care and without haste; otherwise the job is very likely to be unsuccessful.

Where large areas are involved, requiring a large volume of new cement-mortar or concrete, it is essential to apply the latter by the pneumatic process, or by the usual method of constructing forms and filling with concrete, mixed, placed and cured according to standard practice. Pneumatically applied mortar for the restoration of deteriorated surfaces; the filling of interior voids in slabs, piers and walls; the filling of honey-combed shale foundation material beneath piers; and the filling of voids behind tunnel linings, has been successful in some cases and unsuccessful in others. This method requires expert knowledge and the most skilled workmanship.

A successful restoration by means of cast concrete depends largely upon the condition of the old concrete beneath the deteriorated area to be restored. As in patching, all loose and decayed material must be removed until a fairly sound body of concrete has been reached, thus insuring good bond. Horizontal and vertical grooves may then be cut with a narrow chisel, three or four inches apart, and the surface thoroughly cleaned and wetted before deposition of the new concrete.

Shrinkage may be a troublesome factor with this method as well, but if the volume of the new concrete is not great, pre-shrinking may be resorted to. If the volume is large, the concrete should be as dry as it is practicable to place. As in patching, careful attention must be given to the curing, the period to be

long enough to insure against rapid drying of the new concrete. Sometimes drypack mortar is used, either tamped or rammed, or slapped into place by hand.

Reinforcement should consist of mesh or bars, or both, and should be fastened securely to dowels or anchor bolts and located not less than 1 in. from the surface of any concrete that will be subjected to exposure.

In no case should fresh material be applied to a dry surface. The first, or bonding, coat should be composed of one part cement to one part of sand; should be of plastering consistency, plastic at the time of application; should be applied to a thickness of approximately 1/4 in. immediately prior to placement of the body of the new concrete; should be applied to the surface with force and should not be disturbed until the next layer of new concrete is applied.

Successive layers of concrete should be applied in every case while the preceding one, including the bonding coat, is still plastic. If a layer is allowed to harden in place until it has acquired sufficient strength to hold the next layer, the next layer should be applied as a bonding coat.

All trowelling and floating of the plastic finished surface should be done lightly to limit its effect to the surface as far as possible. After the bonding coat has been applied to a horizontal top surface, the concrete should be rammed into place until the cavity is overfilled. The patch should then be further consolidated by hammering on a board in contact with, but extending beyond, the patch. This should be repeated prior to the initial set of the cement; final finishing to be done by light trowelling.

If possible, when packing concrete in forms, it should be placed in layers, each rammed solidly into place while the preceding layer is plastic. Vibrators, if used, should preferably deliver not less than 3 000 impulses per minute.

The committee gratefully acknowledges the assistance given to it by the Portland Cement Association in furnishing a list of references from which a large part of the material for this paper was prepared. Among them are the following :

R. B. Young, *Journal of the American Concrete Institute,* March-April, 1937; F. W. Capp, *Journal of the American Concrete Institute,* May - June 1936; American Railway Engineering Association — *Manual,* 1933.

Discussion.

A. E. Bechtlehimer (C. & N. W.) asked if the committee recommended the waterproofing of new concrete surfaces to prevent deterioration, or only the waterproofing of surfaces which already show deterioration. In reply, Chairman Corey said that some surfaces weather very slowly, but cited several instances where unfavorable water conditions had caused failures of concrete that could have been prevented by waterproofing. He added that he had rarely seen a perfect concrete surface and emphasized the need in most cases of waterproofing before deterioration gets started. Continuing, Mr. Corey cited examples of deteriorated concrete, one being the piers of the Rock Island's old Cimarron River bridge, where the concrete had deteriorated and had been eroded by the water, which contained a large variety of chemicals, among which was a salt content of 0.67 %, successful repairs to these piers being made, he said, by the iron and sal ammoniac method. The other case was a concrete slab of a bridge which had softened prematurely as the result of the use of an aggregate containing aluminite.

A. L. McCloy (P. M.) stated that successful waterproofing of concrete can now be accomplished with several commercial preparations available for that purpose, and called attention in particular to a liquid product which, when

mixed with cement, makes it quick hardening, and adapted to repairing concrete, even against hydrostatic pressure. He also mentioned the effectiveness of cleaning old concrete with muriatic acid before pouring the new concrete in patch work, explaining that the acid attacks the cement and provides a roughened surface.

G. S. Crites (B. & O.) suggested that cleaning with muriatic acid would not be successful with limestone aggregate as the acid would attack the limestone, but that it would undoubtedly be satisfactory where silicious aggregates were involved. G. E. Boyd (*Railway Engineering and Maintenance*) pointed out that where the acid method is used, the concrete must be well washed with water after the application of the acid. He also called attention to the deterioration of concrete by electrolysis and stated that deterioration from this cause, while not common, can be very severe where stray electrical currents are permitted to exist.

O. H. Gosswein (technical service manager of the Universal-Atlas Portland Cement Company) warned that where muriatic acid is used for cleaning concrete, a weak solution (4 %) should be used.

Following questions relative to the effect of sea water on concrete, Chairman Corey said that tests had indicated that sea water does not have as injurious an effect on concrete as water in streams in which the concentration of salt varies widely.

[625. 143.1 & 625.17]

Heavier rail. — Its effect on track labor costs (*).

(Railway Age.)

The effects of heavier rail on track labor are both direct and indirect; this labor is also affected by numerous factors that are independent of the weight of the rail, while some effects of heavier rail, such as that exerted on the life of ties, can be determined only after a considerable number of years. For these reasons, the effect on track labor of increasing the weight of rail cannot be stated statistically without making certain assumptions that are not universal in their application because of the widely varying conditions under which rail is employed.

The committee's study covered a total of 39 roads in the United States and Canada, having a combined line mileage of 226 000. The survey of these roads indicated that while a few of them adopted sections heavier than 100-lb. as far back as 1916 and 1917, the 85, 90 and 100-lb. sections predominated to and including 1920. From 1921 to 1929, however, there was a marked trend toward the adoption of sections heavier than 100 lb. Some roads went directly from 85 and 90-lb. rail to weights of 110 lb or heavier, while others stepped up to 100 lb. and later to the heavier sections. In general, those roads that had adopted 110 and 131-lb. rail during this period changed to the 112 and 131-lb. sections in 1934 or 1935. A few roads did not begin to lay rail heavier than 100 lb. until 1930 or later, while others that were using the 110 and 112-lb. sections

(*) Abstract of a report presented at the convention of the American Railway Engineering Association in March 1939 by a subcommittee of the Committee on Economics of Railway Labor, of which Elmer T. Howson, western editor, *Railway Age* and editor, *Railway Engineering and Maintenance*, was chairman.

also began to use 131-lb. rail on curves, on heavy grades and on lines of densest traffic.

Light rail not standing up.

In general, in arriving at the decision to increase the weight of rail, no consideration was given by the roads under study to the possible savings in track labor, or at most this was a secondary consideration, although every road studied expected that some savings of this character would result. With few exceptions, the primary reason was that, with increasing axle loads and higher speeds of operation, the lighter rail was not standing up, so that stiffer track became a necessity regardless of other considerations. Most of these roads foresaw that with the still heavier wheel loads and higher speeds that were expected, the amount of labor necessary to keep the track to the desired standard, together with all other costs for track maintenance, would increase unless they adopted heavier rail. Several roads based their decisions to use heavier rail on studies showing that the life of the rail could thus be prolonged sufficiently to make the added investment economical on a capitalized yearly cost basis, and ignored the possible favorable results on labor costs and on costs for other items of the track structure.

High speeds increase need for heavy rail.

Obviously, in the cases which have been mentioned the original installations of the heavier rail were confined to districts having the greatest density of traffic, and on not a few roads they were not extended beyond such districts, lighter sections still being purchased for use on primary lines of lighter traffic. Beginning with 1934, however, a new factor was introduced with the sharp increases that were made in the speeds of both passenger and freight trains, for smooth-riding track and assurance against track defects that might endanger safety at high speed have become paramount on those lines over which high-speed trains are being operated. For this reason, there has been a noticeable trend toward the extension of heavy rail sections to lines of lighter traffic. Thus it was possible to study the effects of heavier rail on track labor under a wide variety of conditions.

Owing to the increase in stiffness, both vertically and laterally, as the weight of the rail increases, and the consequent better distribution of the traffic loads over the ballast, other conditions being equal, there is a considerable reduction in the amount of labor required to keep the track in line and surface. The committee found, however, that the amount of this reduction varies within relatively wide limits by reason of variations in physical conditions and the volume and character of the traffic. None of the roads under study compiled records that showed definitely the magnitude of this reduction, although the testimony was general that it has been substantial. Estimates by responsible maintenance officers of the reduction in the labor item ranged from 20 to 50 %. It was found that the savings in this item vary rather definitely with the volume of traffic and the speed of trains, increasing as the volume and speed of traffic increase.

While a large part of the reduction in the amount of labor required for lining and surfacing can be attributed directly to the stiffness of the rail and a better distribution of the loads on the ballast, it must be recognized that there are also indirect reasons for this reduction, as well as causes in no wise connected with the weight of the rail. The larger sections provide deeper fishing space and, therefore, stronger joints; the large tie plates that accompany the heavy rail reduce the wear on ties and tend to hold gage better, and where the tie plates are fastened independently of the rail fastenings this wear is still further re-

duced and there is less widening of the gage; new ties are pre-adzed and when rail is renewed modern practice demands the use of mechanical adzers, thus providing a better and more uniform bearing for the tie plates and rail; and stronger joints reduce the churning of the ballast at the joints. However, it is not possible to evaluate these items, either individually or in combination, or to estimate with any degree of accuracy the extent to which they affect the labor required for lining and surfacing.

Heavy rail outlasts lighter sections.

Experience has shown that under average main-line conditions the life of heavy rail is greater than that of light rail, the length of the increased life being dependent on a number of factors. One of the roads under study based its decision to apply 130-lb. rail in place of 100-lb. rail on the annual capitalized cost of the rail and ignored the possible saving in the cost of track labor. On a district having a traffic of 23 000 000 gross tons per mile of track per year, it was calculated that, since the 100-lb. rail had an average life of 5 1/2 years, the 130-lb. section would have to last 8 1/2 years, or 55 % longer, to equalize the cost. As a matter of record, the 131-lb. rail has now been in service for 9 years with no removals and the minimum life will be at least 10 years, with the average considerably more.

This illustrates a situation that has a definite bearing on the effect of heavier rail on track labor, for where the life of the rail is increased 50 %, compared with the light rail it displaces, the labor cost of rail renewal is reduced by one-third; if the life is doubled the labor cost for this item is cut in half; and if the life of the rail can be extended 2 1/2 times, the labor for laying rail will be 60 % less. Actual experience in the saving effected in this item of track labor ranged from 20 to 60 %.

Life of ties increased.

Increasing the weight of rail lengthens the life of ties by decreasing the abuse to which they are subjected in service. By reason of its greater girder strength, the larger rail distributes the traffic load over a greater number of ties, thus reducing the load on the individual ties. Although they are entirely independent of but usually incidental to heavy rail, large tie plates also contribute to decreasing the intensity of pressure on the ties by spreading the reduced load over a greater area of the surface of the ties. Ties fail in large numbers as a result of abrasion induced by relative movement between the tie plate and the tie, and this mechanical action is greatly increased by the wave motion in the rail. Since the heavy rail is stiffer, it has less wave motion and thus prolongs the life of those ties that fail from plate cutting.

Spike cutting is another fertile source of tie failure, and because rail renewals are less frequent and less gaging is required with the heavier rail and larger tie plates, the life of ties subject to this type of failure is prolonged. Because of the many other factors that affect tie life, however, such as the species of wood, the type of treatment, the practice of pre-adzing and pre-boring, the character and condition of the ballast and others that are in no wise related to the weight of the rail, it is not possible to state in concrete terms the effect of increased weight of rail on the labor involved in tie renewals, although it is clearly apparent that the heavy rail will result in an increase in the life of ties, and thus effect a reduction in the labor required for tie renewals.

Owing to the greater girder strength of the rail itself and to the opportunities the higher fishing affords for better joint design, it is the general experience that an increase in the weight of rail tends to decrease the amount of labor required for picking up joints. There is also a reduction in the labor required

for reconditioning the joints and replacing joint bars where heavy rail is used. The effect on labor of this item varies almost directly with the volume of traffic, axle loading and speed.

Heavy rail saves ballast.

Lack of stiffness accentuates wave motion in rail under the rolling wheel loads, thus causing increased vertical movement in the ties. Investigation has shown that the intensity of the blow delivered by the tie to the ballast bed under fast moving trains varies approximately as the square of the amplitude of the wave motion, that is, as the vertical distance the tie moves. These repeated blows tend to drive dirt up from the subgrade through the ballast and foul it. Then, with favorable conditions of moisture, churning results. While churning may, and frequently does, occur at any tie, it is more frequent and generally more aggravated around the joints.

Since the greater stiffness of the heavy rail reduces the amplitude of the wave motion and, therefore, the vertical movement of the ties, churning is reduced and the amount of labor involved in surfacing the track, over and above ordinary maintenance requirements, is eliminated or reduced. The committee obtained no information as to the magnitude of this excess labor requirement over ordinary maintenance but referred to a previous report by the Committee on Ballast in which it was stated that the cost of maintaining churning track (joints) is from 2 1/2 to 4 times that for track in which there are no pumping joints.

Furthermore, after churning track has been surfaced repeatedly, it becomes necessary either to clean or discard the existing ballast, give the track a general raise, and restore the ballast section. This work calls for a large expenditure of labor. Increasing the weight of rail reduces the tendency of the track to churn and increases the intervals between general surfacings, with a consequent appreciable saving in labor.

A measure of economy.

In its report for 1930, the Rail Committee included a monograph by A. N. Reece, chief engineer, of the Kansas City Southern, giving the results of a study to determine the economic weight of rail for that road. Five weights of rail were placed under study, including 85-lb., the existing standard for the road; 100-lb., 115-lb. and 127-lb., which were laid for experimental purposes; and the 150-lb. R. E. section. Largely from data obtained in field tests, it was concluded that the effect on track labor of increasing the weight of rail would be as shown in Table I. As a result of this study, it was determined that 137-lb. rail would be the most economical section, but for reasons stated in the monograph 127-lb. rail was chosen. At that time (1927) the gross ton-miles per mile of road on the districts where the 127-lb. rail was laid ranged from 4 560 000 to 6 330 000. In response to an inquiry as to the eco-

TABLE I. — **Kansas City Southern.**

Effect on track labor of increasing the weight of rail.

Rail section.	Track rating (%)	Labor per mile per year (man-hrs.).	Comparative maintenance labor (%)	Cost of labor per mile per million G. T. M.	Saving per mile per million G. T. M.
8521 . .	34	3 150	100	$ 120	$ 0
10025 . .	50	1 950	62	74	46
11522 . .	62	1 470	47	56	64
12722 . .	67	1 280	41	49	71
15025 . .	80	950	30	36	84

nomies in track labor actually effected by reason of the increased weight of rail, the committee was advised as follows :

« In 1935, when the volume of traffic had increased from the low point of the depression, the railway made another study of the economics of heavy rail, the traffic for this year being selected in the expectation that it would be the average for a number of years. During 1935, the minimum gross ton-miles per mile of road on districts where the 127-lb. rail was in service was 2 840 000 and the maximum 4 740 000. Table II shows the cost of track labor (all items) per mile per million gross ton-miles for each weight of rail and the saving compared with the cost for the 85-lb. section. In this study the traffic density was taken as 3 130 000 gross tons per mile of road. »

The committee was advised further that « the unit measure of economy shown in the tables is labor per mile per million gross tons, which is indisputably the most uniform measure obtainable because traffic density, physical characteristics and all other factors are included. The use of heavier rail has made it possible to reduce the labor force and lengthen sections. This latter reduction in force can be accomplished during periods of light traffic and to take advantage of well-built track and high standards of maintenance to carry through periods of low revenue. By measuring economy in gross ton-miles of traffic, the result is more positive. However, expressing labor in the usual terms, it was found that when a section is laid with 85-lb. rail, its length must be reduced by about five track miles or, by comparison, the same gang can maintain five more miles of 127-lb. rail ».

A record of heavy rail.

On the Bessemer & Lake Erie the committee found another clear-cut record that shows quite definitely the effect of heavier rail on track labor. In 1917, this road began to replace 100-lb. rail with a section weighing 130 lb., and by 1921, about 60 % of the main-track mileage had been laid with the heaver rail. There was a decided reduction in man-hours of track labor beginning with 1922, with a continuing decrease as more of the heavier rail was laid. The life of the 100-lb. rail was six years, while that of the 130-lb. rail is 13 years, which has reduced the cost of laying rail by more than 50 %.

Table III shows for this road the gross ton-miles per mile of road per year, the man-hours for all items of track labor and for track laying and surfacing only, and the relative reduction that has been made in these items for the period from 1917 to 1931, inclusive. This statement

TABLE II. — **Kansas City Southern.**

Estimated cost of track labor for various weights of rail in 1935.
Based on actual costs for 85-lb rail.)
Compared with estimated costs in 1927.

	Cost of labor per mile per million G. T. M.		Saving per mile per million G. T. M.	
Rail section.	1927 est.	1935 act.	1927 est.	1935 act.
8521	$ 120	$ 79	$ 0	$ 0
10025	74	49(*)	46	30(*)
11522	56	37(*)	64	42(*)
12722	49	32(*)	71	47(*)
15025	36	24(*)	84	55(*)

(*) Estimated from actual costs for 85-lb. rail.

TABLE III. — **Bessemer and Lake Erie.**

Statement of G. T. M. per mile of road, track department, strict maintenance man-hours,and account No. 220, strict maintenance man-hours, for the years 1917 to 1930, inclusive.

Year.	G. T. M. per mile of road.	Track dept. strict M. W. & S. man-hours.	Ratio to 1917.	Acct. No. 220 (*) strict M. W. & S. man-hours.	Ratio to 1917
1917 . . .	19 173 838	1 765 816	100.0	1 256 849	100.0
1918 . . .	17 805 087	1 741 743	98.6	1 261 588	100.4
1919 . . .	15 218 810	1 460 326	82.7	1 209 411	96.2
1920 . . .	15 846 963	1 394 059	78.9	1 066 525	84.9
1921 . . .	13 124 953	1 252 451	70.9	1 039 375	82.7
1922 . . .	15 284 593	930 399	52.7	711 052	56.6
1923 . . .	20 931 885	1 036 976	58.7	810 564	64.5
1924 . . .	16 405 542	1 142 754	64.7	867 368	69.0
1925 . . .	18 627 945	956 280	54.2	715 816	57.0
1926 . . .	19 306 343	941 446	53.3	705 595	56.1
1927 . . .	17 074 310	914 985	51.8	675 792	53.8
1928 . . .	18 302 893	840 254	47.6	585 430	46.6
1929 . . .	20 300 595	870 827	49.3	611 612	48.7
1930 . . .	16 507 213	796 996	45.1	589 745	46.9
1931 . . .	9 697 515	704 657	39.9	501 991	39.9

was confined to the years prior to 1932 because the effect on track labor of the use of treated ties, which was started in 1928, was becoming apparent, while the improvement in ballast conditions, which had its beginning in the same year, was also beginning to show its effect. Again the adoption of new maintenance methods about 1930, combined with the ties and ballast, made it impossible even approximately in subsequent years to assign to the heavier rail its share in the continued reduction in track labor. By confining it to the period prior to 1932, therefore, the record affords a reliable indication of the reduction that can be effected in track labor through increased weight of rail alone.

While the remaining roads under study did not have as definite records of the reductions that have been made in track labor by reason of the adoption of heavy rail, with the exception of one road, the maintenance officers of these roads were unanimous that substantial reductions have been realized, the estimates for all items of track maintenance ranging from 20 to 60 %. Some of the roads conceded that where a high density of traffic prevails, the saving in labor is sufficient to justify the investment in heavy rail. For lines of lighter traffic, this justification becomes less pronounced and finally reaches a point, which must be defined in the light of each particular case, where considerations other than the saving in labor must participate to justify the increase in weight.

Conclusions.

1. The use of heavy rail in heavy-traffic, high-speed lines reduces the amount of labor necessary to maintain a given standard of track excellence.

2. This reduction is both direct and indirect. The items affected directly include line, surface, gage, joint maintenance and laying rail. The items affected indirectly include tie renewals, cleaning ballast and ballast renewals.

3. Since the labor required for practically every item of track maintenance is affected also by factors that have no relation to the weight of the rail, it is impossible to segregate those factors in

(*) Track laying and surfacing.

such a way that the effect of the heavy rail alone can be evaluated.

4. The magnitude of the economy that can be realized from increasing the weight of rail depends on the relative stiffness of the heavy rail and of the lighter rail that it displaces, the volume of traffic, the axle loads and the speed of trains.

5. For lines of high traffic density, the saving in track labor following the installation of 112- and 131-lb. sections in place of sections weighing 100 lb. and lighter may reach 40 % of the total expenditure for this item. As the volume of traffic decreases, this saving also decreases until a point is reached where considerations other than savings in labor must justify the increase in weight of rail.

[621. 338 (.45)]

Recent developments on the Italian State Railways.

(*Engineering.*)

The programme for the extension of electrification on the Italian State Railways, which has been in hand for a number of years, was taken several stages nearer to completion in 1939. In particular, mention may be made of the inauguration of electric traction, on October 28, on the line running through Chiasso, Milan and Voghera, which will enable trains from the Swiss frontier, via the St. Gothard tunnel, to proceed directly to the south of Italy; and of the Falconara-Orte line, which provides a subsidiary electrified connection between the north and south of the country. The completion of these two sections increased the total length of the Italian electrified system from 4 823 km. (3 000 miles) at June 30, 1939, to 5 131 km. (3 188 miles) on October 28. Both of the new lines are supplied with direct-current at 3 000 volts through substations equipped with mercury-vapour arc rectifiers. One of these substations is situated at Milan, where the electrification of the railway station has involved a considerable amount of work. Monza station has been altered for electrified working, and Voghera station, where the direct-current system connects with the alternating-current system, has been replanned. The work on the Falconara-Orte line has required the reconstruction of several tunnels and the regrading of portions of the track.

The electrification programme of the Railways Administration provides for the conversion of a further 2 400 km. (1 491 miles) of track by the end of 1942, and it is expected that this will enable a reduction of 2 500 000 tons in the annual imports of coal, or about 20 % of the present total : this is in addition to the reduction of 1 700 000 tons effected during 1938 and 1939. During the same two years, the operation of the electrified lines used about 1 000 million kWh. of current, of which some 890 million kWh. were supplied by privately-owned plants. To cover future power requirements, the Administration have made arrangements to increase the available supply of current to 1 500 million kWh. The speed of main-line traffic has been appreciably increased as a consequence of electrification. Between Rome and Naples, a speed of 123 km. (76 miles) per hour is now attained, and between Rome and Bologna, 125 km. (78 miles) per hour, as against the previous maximum of 117 km. (73 miles) per hour. The journey time between Milan

and Naples has now been reduced to 7 h. 26 m., including 11 minutes lost in stops at Bologna, Florence and Rome. Express freight services also have been introduced, running, for example, at 90 km. (56 miles) per hour on the line from Reggio to Rome. Where previously the through trains carrying vegetables and fruit from Sicily to the Brenner district took 105 hours, the journey is now made in less than 50 hours.

Among the constructional works undertaken on the State Railway system have been the building of the new Central and Maritime station at Messina and the re-organisation of the various stations in Rome, the latter works including the construction of a goods line from Roma Tiburtina to Settebagni and of the Roma Littorio marshalling yard. Passenger stations have been rebuilt at Turin, Alessandria, Udine, Carrara, Siena, Bari, Reggio Calabria, and about a dozen other towns. The new terminus at Venice is still under construction, as well as the enlargement of the stations at Trieste and Genoa. On several lines the signalling system has been entirely renewed, and the track between Narni and Terni has been doubled. During 1938 and 1939, the builders of rolling stock have delivered 137 electric locomotives, 47 electric railcars, 4 streamlined trains, 20 train sets, and 50 diesel-engined railcars; and, in addition, they have fitted continuous brakes to 12 000 freight cars.

On the line between Milan and Bologna, experiments are being carried out with railcars driven by gas engines using methane; and between Genoa and Milan, similar tests are being made with railcars fitted with a type of gas engine, supplied by producers using charcoal, which has been developed by the Società Anonima Ansaldo. If these trials are satisfactory, it is intended that engines of this type shall be used to replace the diesel-engined railcars, in order to reduce the consumption of oil, which must be imported. In addition to these new departures in railway practice, the works of Messrs. Piaggio, at Genoa Sestri, are engaged on the construction of stainless-steel passenger coaches and of two train sets, also in stainless steel, under licence from Messrs. Budd and Company, of Philadelphia.

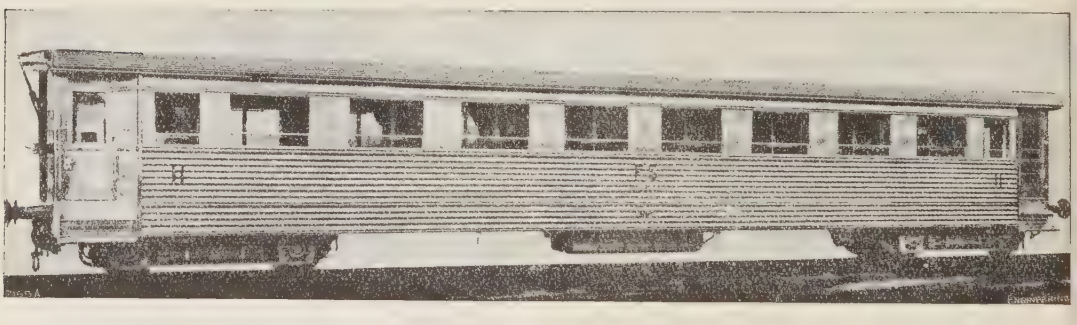


Fig. 1. — General view of stainless steel coach.

The stainless-steel coaches are to be used on the main lines, both in complete trains and also in conjunction with other stock, the coupling and braking arrangements being identical with those of the existing coaches used in the main-line trains. The main dimensions of the new stock, illustrated in Figs. 1 to 4, are : length over buffers, 21.825 m. (71 ft. 7 in.); extreme breadth, 2.957 m. (9 ft. 8 1/2 in.); height above rail level, 3.71 m. (12 ft. 2 in.); height from rail level to coach floor level, 1.247 m. (4 ft.

1 in.); length between bogie centres, 15.485 m. (50 ft. 9 1/2 in.); and centres of bogie wheels, 2.70 m. (8 ft. 10 in.). The wheels are 0.90 m. (2 ft. 11 1/2 in.) in diameter. The weight of each car, ready for service, is 18 tons, as against the 44 tons of existing coaches, of similar dimensions, in use on the Italian State Railways. Particular importance is attached to this reduction of weight, as it is estimated that the smaller weight of the new coaches will result in a saving of 18 000 lire per annum in the cost of haulage, apart from the anticipated reduction in maintenance costs and the smaller quantity of metal required for the construction of the stock.

As can be seen from the illustrations, the coaches are of the end-vestibule type, with four-wheeled bogies, and have two doors at each end. The equipment includes automatic brakes on the Breda system, operated by compressed air and designed for braking at high train speeds; an alarm signal which also applies the brakes; and a hand brake, acting on all the wheels, operated from one of the vestibules. A Westinghouse

Fig. 2. — Four-wheeled bogie.

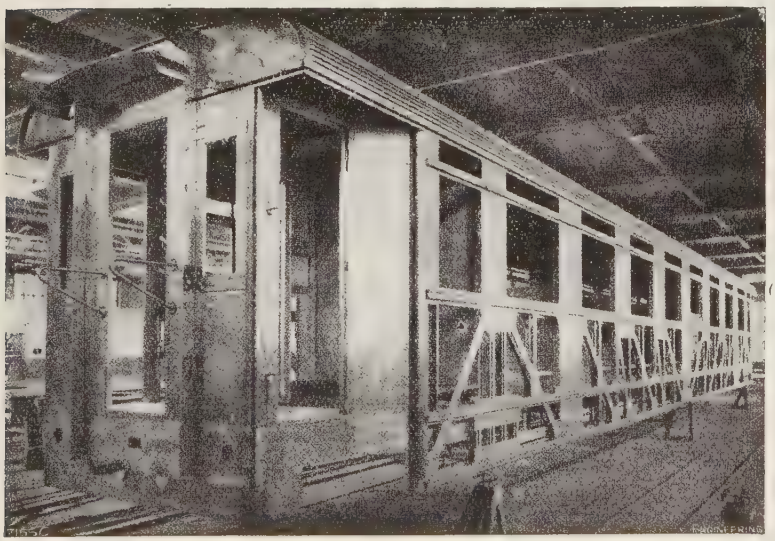


Fig. 3. — Framework of coach body.

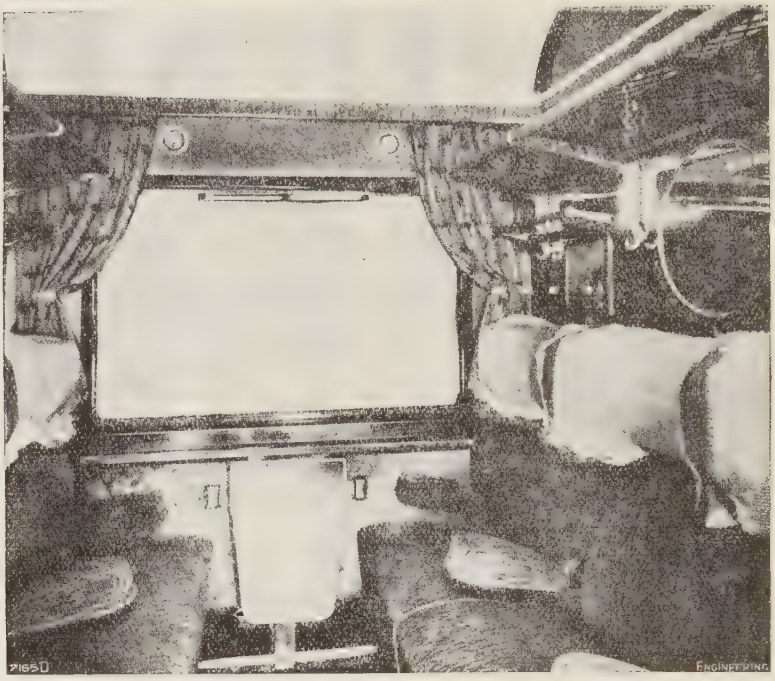


Fig. 4. — Interior of first-class compartment.

steam-heating plant is fitted, and accumulators for lighting purposes. The bogies, one of which is shown in Fig. 2, are of riveted construction, in mild steel, and weigh 5 500 kgr. (5 tons 8 cwt.) each. The suspension consists of leaf springs. The axle bearings are of the R. I. V. type, and support the bogie frame through a system of double springs. The framework of the coach body, the construction of which is illustrated in Fig. 3, is of stainless steel, welded throughout, and is covered with stainless-steel sheets, designed to be readily removable. The main longitudinal and transverse members are also of stainless steel. The walls, ceiling and floor are covered with insulating and anti-vibration material. The interior furnishings are constructed in mahogany, with non-corrodible metal fittings, and the window frames are of stainless steel. Ventilating sashes are provided, and are fitted with balancing devices to hold them in position. The flooring consists of corrugated stainless-steel sheets, fitted with Litosilo, over which are laid felt, linoleum and a woollen carpet. A lavatory compartment is situated at each end of the coach. The compressed-air brake cylinder is carried under the framing in the usual manner and actuates the two brake blocks on each wheel through rigging of the type now standard on the State Railways' coaching stock.

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ielques **problèmes de chemins de fer.** Leur solution dans le cadre de la Société Nationale des chemins de fer. (16 000 mots & fig.)

Bulletin de l'Union Internationale des chemins de fer. (Paris.)

1939 385 .113 (.493)
Bull. de l'Union intern. des ch. de fer, août, p. 248.
La **Société Nationale des Chemins de fer belges** en 1938. (6 000 mots.)

(1) The numbers placed over the title of each book are those of the decimal classification proposed by the Railway Congress jointly with the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to Railway Science », by L. WEISSENBRUCH, in the number for November 1897, of the *Bulletin of the International Railway Congress*, 1509).

1939 **656 .1 (.42)**
Bull. de l'Union intern. des ch. de fer, août, p. 265.
Le **réseau routier** anglais. (3 000 mots.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1939 **313 .385 (.43)**
Bull. des transp. intern. par ch. de fer, octobre, p. 435.
Les **chemins de fer allemands** pendant l'exercice 1937. (900 mots.)

1939 **313 .385 (.494)**
Bull. des transp. intern. par ch. de fer, novembre, p. 477.
Les **Chemins de fer fédéraux suisses** en 1938. (1 900 mots.)

Bulletin technique de la Suisse romande. (Vevey.)

1939 **656 .261**
Bull. tech. de la Suisse romande, n° 22, 4 novembre, p. 281.
HOFFET (Ch.). — Le **transport de wagons sur la route.** (2 300 mots & fig.)

Economie et technique des transports. (Lucerne).

1939 **625 .2 : 625 .62 (.45)**
Economie et technique des transports, août-septembre, p. 69.
FERRARI (R.). — Le **service du matériel roulant des tramways municipaux** de Milan. (700 mots & fig.)

Génie civil. (Paris.)

1939 **62. (01 & 669**
Génie civil, n° 2986, 4 novembre, p. 333; n° 2987, 11 novembre, p. 355.
FLUVOT (J.). — La **détection magnétique des défauts dans les alliages métalliques.** (7 000 mots & fig.)

1939 **621 .33 (.3)**
Génie civil, n° 2987, 11 novembre, p. 353.
PONDEVEAUX (L.). — Le développement de l'électrification **des chemins de fer** dans le monde. L'exemple de l'Italie. (3 000 mots.)

1939 **62. (01 & 669**
Génie civil, n° 2987, 11 novembre, p. 361.
Recherches sur le **mécanisme structural du comportement des métaux aux températures élevées.** (560 mots.)

1939 **621 .132.3 (.59)**
Génie civil, n° 2988, 18 novembre, p. 375.
Les nouvelles **locomotives « Pacific »** des chemins de fer de l'Indochine. (780 mots.)

L'Ossature métallique. (Bruxelles.)

1939 **624 (.493)**
L'Ossature métallique, novembre, p. 465.
DE CUYPER (G.). — Les **ponts métalliques** du canal Albert. (5 300 mots & fig.)

1939 **626 (.**
L'Ossature métallique, novembre, p. 489.
SANTILMAN (H. N. F.). — Les principaux **ouvr d'art hydrauliques du canal Albert.** (5 400 mots &

Revue générale des chemins de fer. (Paris

1939 **385. (09.1 (**
Revue générale des chemins de fer, octobre, p. 20
CUNÉO. — Le **chemin de fer de Dakar au N** (6 000 mots & fig.)

1939 **621 .87 (.44) & 625 .245 (**
Revue générale des chemins de fer, octobre, p. 22
BRÉAU. — La **grue de relevage** de 130 tonnes Société Nationale des Chemins de fer français. (mots & fig.)

In German.

Der Bahn-Ingenieur. (Berlin.)

1939 **656 .2**
Der Bahn-Ingenieur, Nr. 45-46, 5-12. November. S.
DIEDERICH. — **Zugverspätungen und Fahrze ermittlung.** (6 000 Wörter, Taf. & Abb.)

1939 **625**
Der Bahn-Ingenieur, Nr. 45-46, 5-12. November, S.
BOTHE. — Mechanische Hilfsmittel für **Bett erneuerungsarbeiten.** (1 900 Wörter & Abb.)

Die Lokomotive. (Berlin).

1939 **621 .132.8**
Die Lokomotive, Heft 8, November, S. 173.
BANGERT (P. H.). — Neuartige **Dampflokomo für den Abraumbetrieb.** (2 750 Wörter & Abb.)

Die Reichsbahn. (Berlin.)

1939 **625 .4**
Die Reichsbahn, Heft 42-43, 18.-25. Oktober, S. 9
GRABSKI. — Vom Bau der **Berliner Nordsüd-S-** (4 200 Wörter & Abb.)

Elektrische Bahnen. (Berlin.)

1939 **621 .331**
Elektrische Bahnen, Heft 9, September, S. 215.
KOTHER (H.). — Die **Stromversorgung** der Ita schen Staatsbahnen. (6 300 Wörter & Abb.)

1939 **62**
Elektrische Bahnen, Heft 9, September, S. 223.
KOTHER (H.). — **Elektrische Bahnen** für schnellverkehr. (6 200 Wörter, Tab. & Abb.)

1939 **621 .335 (.43) & 621 .337**
Elektrische Bahnen, Heft 10, Oktober, S. 229.
MAHR (K. J.). — **Elektrische Lokomotiver** handbetätigter Nockenschaltwerksteuerung für Strecke Murnau-Oberammergau. (3 200 Wörter &

Glasers Annalen. (Berlin.)

39 **621 .139 (.43), 625 .18 (.43) & 625 .27 (.43)**

ers Annalen, Heft 19-20, 1.-15. Oktober, S. 247.

RENZ. — Das **Abnahmewesen** der Deutschen isbahn. (5 300 Wörter & Abb.)

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39 **62 .01 (.43)**

ers Annalen, Heft 19-20, 1.-15. Oktober, S. 252.

JHNEL. — **Werkstoffprüfung** bei der Deutschen isbahn. (1 200 Wörter.)

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39 **62. (01 & 621 .392**

ers Annalen, Heft 19-20, 1.-15. Oktober, S. 256.

TIELER (C.). — Verfahren zur **zerstörungsfreien** ung von Werkstücken, besonders von Schweiss-en. (5 400 Wörter & Abb.)

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39 **62 .01 (.43)**

ers Annalen, Heft 21, 1. November, S. 264.

CHARNBECK (W.). — Die **Prüfung nichtmetalli-r Stoffe** bei der Deutschen Reichsbahn. (5 200 Wör-& Abb.)

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leistechnik und Fahrbahnbau (Karlsruhe.)

39 **625 .14**

stechnik und Fahrbahnbau, Heft Nr. 21-22, 15. No-vember, S. 157.

OSENTRUP (H.). — Beitrag zur **Berechnung** des **baues.** (1 900 Wörter & Abb.)

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an für die Fortschritte des Eisenbahnwesens. (Berlin.)

39 **62. (01 & 625 .2**

n für die Fortschr. des Eisenbahnwesens, Heft 21, 1. November, S. 403.

ASCHINGER (O.). — Festigkeits- und Zerstörungs-uche an **Wagenkasten.** (9 900 Wörter & Abb.)

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39 **385. (072 (.43)**

n für die Fortschr. des Eisenbahnwesens, Heft 22, 15. November, S. 419.

ASPEROWSKI (O.). — Das **elektrotechnische Ver-samt** der Deutschen Reichsbahn beim Reichsbahn-ralamt München. (2 600 Wörter & Abb.)

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39 **625 .216 (.43)**

n für die Fortschr. des Eisenbahnwesens, Heft 22, 15. November, S. 422.

ENNINGS. — Die **Zug- und Stossvorrichtungen** an neuen Wagen der Deutschen Reichsbahn. (3 300 ter & Abb.)

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39 **625 .251**

n für die Fortschr. des Eisenbahnwesens, Heft 22, 15. November, S. 428.

RSCHSTEIN. — Die **Reibung von Bremsklötzen** hoher Geschwindigkeit und hohem Druck. (1 850 ter & Abb.)

Verkehrstechnische Woche. (Berlin.)

1939 **625 .4 (.43)**

Verkehrstechnische Woche, Heft 40-42, 4.-18. Oktober, S. 443.

GRABSKI. — Der Bau der **Berliner Nordsüd-S-Bahn.** Ein Rückblick. (4 500 Wörter & Abb.)

1939 **625 .4 (.43)**

Verkehrstechnische Woche, Heft 40-42, 4.-18. Oktober, S. 452.

CAPELLE (G.). — Über **Betriebs- und Verkehrsfragen** der Nordsüd-S-Bahn. (6 200 Wörter & Abb.)

Zeitschrift des Vereines deutscher Ingenieure (Berlin.)

1939 **621 .33**

Zeitschr. des Ver. deutsch. Ing., Nr. 46, 18. November, S. 1221.

CURTIUS (E. W.). — Neuer Messwagen zur **Untersuchung elektrischer Fahrzeuge** für hohe Geschwindigkeiten. (1 650 Wörter & Abb.)

1939 **621 .134.1**

Zeitschr. des Ver. deutsch. Ing., Nr. 46, 18. November, S. 1223.

REITER (M.). — **Geschweisste Lokomotivzylinder.** (850 Wörter & Abb.)

Zeitung des Vereins mitteleuropäischer Eisenbahnverwaltungen. (Berlin.)

1939 **656 (.4)**

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 44, 2. November, S. 777.

SCHUBERT. — Das Grundproblem im **Güterverkehr zu Lande** in Europa. (6 000 Wörter.)

1939 **385 .63**

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 45, 9. November, S. 789.

ROSENBERG (E.). — Besondere Zusatzbestimmungen zum I. Ü. G. in **Verbandstarifen.** (2 400 Wörter.)

1939 **385 .15 (.485)**

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 45, 9. November, S. 792.

PASZKOWSKI. — Die Entwicklung der **schwedischen Privatbahnen** in den Jahren 1934-1938. (2 200 Wörter.)

In English.

Bulletin, American Railway Engineering Association. (Chicago, Ill.)

1939 **621 .39 (.73)**

Bulletin, American Railway Engineering Association. No. 412, September-October, p. 1.

Reports of the Committees of the Electrical Section, Engineering Division. — **Power supply.** — Overhead **transmission line** and **catenary construction.** — **Standardization of apparatus and materials.** — Application of **motors.** — **Protective devices and safety rules** in electrified territory. — Track and 3rd **rail bonds.** — Design of indoor and outdoor **substations.** — Application of **corrosion-resisting material** to railroad electrical construction, etc. (35 000 words, tables & fig.)

1939 **624 .2**
Bulletin, American Railway Engineering Association, No. 412, September-October, p. 81.
WILSON (W. M.). — Design of **connection angles for stringers of railway bridges.** (5 200 words & fig.)

1939 **385 .11 (.73)**
Bulletin, American Railway Engineering Association, No. 412, September-October, p. 99.
WENDT (Edwin, F.). — **Federal valuation of railroads.** Development of state and federal regulation of railroads in the U. S. A. (30 000 words.)

Engineer. (London.)

1939 **621 .132.1 (.42) & 656 .222.1 (.42)**
Engineer, No. 4371, October 20, p. 390; No. 4372, October 27, p. 414; No. 4373, November 3, p. 438; No. 4374, November 10, p. 466 and No. 4375, November 17, p. 486.
LIVESAY (E. H.). — **Scottish locomotive experiences.** (28 800 words & fig.)

1939 **621 .431.72 & 625 .28**
Engineer, No. 4373, November 3, p. 454 and No. 4374, November 10, p. 479.
RIPLEY (C. T.). — **High-speed lightweight trains.** (10 500 words, tables & fig.)

1939 **624 .51 (.73)**
Engineer, No. 4374, November 10, p. 462 and No. 4375, November 17, p. 487.
The Bronx-Whitestone **suspension bridge.** (6 500 words & fig.)

1939 **662**
Engineer, No. 4374, November 10, p. 469.
Fuel technology and the war. (3 500 words.)

1939 **629 .113 & 662**
Engineer, No. 4374, November 10, p. 473.
Home-produced fuel for road vehicles. (1 800 words.)

1939 **621 .431.72 (.68) & 625 .616 (.68)**
Engineer, No. 4375, November 17, p. 504.
78-H.P. **narrow gauge locomotive.** (400 words & fig.)

Engineering. (London.)

1939 **656**
Engineering, No. 3849, October 20, p. 446.
Road and rail transport problems. (2 100 words.)

1939 **621 .132.3 (06 (.54)**
Engineering, No. 3850, October 37, p. 476; No. 3851, November 3, p. 506; No. 3852, November 10, p. 533.
The report of the Pacific Locomotive Committee. (19 100 words & fig. (To be continued.)

1939 **651 (.42)**
Engineering, No. 3850, October 27, p. 459.
Letter-sorting machines at the Brighton General Post Office. (7 400 words & fig.)

1939 **388 (.42)**
Engineering, No. 3851, November 3, p. 504.
London passenger transport. (2 300 words.)

1939 **625 .13 (.73) & 2 625 .42**
Engineering, No. 3851, November 3, p. 508.
Welded steel tunnel section for Chicago sub
(600 words & fig.)

1939 **621 .431.72 (.68) & 625 .616 (**
Engineering, No. 3852, November 10, p. 537.
78-H.P. **narrow-gauge oil locomotive** for South A
(450 words.)

1939 **623 & 625 .232 (**
Engineering, No. 3852, November 10, p. 537.
British **ambulance trains.** (1 050 words.)

Engineering News Record. (New York.)

1939 **62 (01 & 62**
Engineering News-Record, No. 15, October 12, p. 6
SACK (N. R.). — **Probing for bridge foundat**
(2 800 words & fig.)

1939 **625 .13 (**
Engineering News-Record, No. 15, October 12, p. 7
An important **tunnel lining study.** (1 500 word
fig.)

1939 **624 .1 (.73) & 721 .1 (.**
Engineering News-Record, No. 17, October 26, p. 5
Driven cylinder foundations built rapidly. (1
words & fig.)

Journal, Institution of Civil Engineers.

1939 **62**
Journal of the Institution of Civil Engineers, No
October, p. 279.
GALES (Sir Robert R.). — Paper No. 5167. « **principles of river-training for railway bridges,** their application to the case of the Hardinge br over the Lower Ganges at Sara » (correspondenc connection with). (30 000 words & fig.)

1939 **624.**
Journal of the Institution of Civil Engineers, No
October, p. 466.
BAILEY (A.) and VINCENT (N. D. G.). — P
No. 5187 « **Wind-pressure experiments at the Se Bridge** » (correspondence in connection with). (1 words.)

1939 **624 .3 (.**
Journal of the Institution of Civil Engineers, No
October, p. 469.
MAUNSELL (G. A.) and PAIN (J. F.). — P
No. 5197 « **The Storström Bridge** » (correspondenc connection with). (1 700 words & fig.)

Journal, Permanent Way Institution. (Lond

1939 **62 (01 (.42) & 625 .1 (**
Journal, Permanent Way Institution, August, Par
p. 179.
TURNER (T. H.). — **Permanent way metallu**
(13 600 words, tables & fig.)

625 .172
l, Permanent Way Institution, August, Part II, 214.
TELEY (J. W.). — **Track defects — Their tion and cure.** (5 000 words.)

625 .142.3
l, Permanent Way Institution, August, Part II, 224.
l sleepers — A symposium :
CARPMAEL (R.). — Some notes on the **use el sleepers.**
HUDSON (J. C.). — Service observations on the ; of ordinary and copper-bearing steel sleepers e Corrosion Committee of the Iron and Steel te, and the British Iron and Steel Federation.
THOMAS (T. J.). — **Steel sleepers for bull-head ack.**
EASTY (A.) — **Relaying and maintenance of leepered tracks.**
CARN (A. E.). — **Maintenance of steel-sleepered** (8 600 words, tables & fig.)

Journal and Proceedings, Institution of Mechanical Engineers. (London.)

621 .436
l & Proceedings, The Institution of Mechanical gineers, Vol. 141, No. 6, October, p. 519.
FEN (E.) and ROWE (A. W.). — **Pressure cal-ns for oil engine fuel-injection systems.** (11 000 tables & fig.)

621 .436
l & Proceedings, The Institution of Mechanical gineers, Vol. 141, No. 6, October, p. 535.
IES (S. J.). — Recent developments in **high-oil engines.** (9 300 words & fig.)

Mechanical Engineering. (New York.)

621 .132.8 (.73) & 621 .335 (.73)
nical Engineering, October, p. 709; November. 817.
DWARD (A. J.) and CAIN (B. S.). — Design Union Pacific **steam-electric locomotive.** (6 500 & fig.)

Modern Transport. (London.)

656 (.66)
n Transport, No. 1075, October 21, p. 3.
sport conditions and problems in Nigeria. In-tor recommends reorganisation; new method of ; central co-ordinating authority required. words.)

351 .812 & 656 .23 (.43)
n Transport, No. 1075, October 21, p. 4.
ANNEY (L.). — **Goods transport by rail and** No. 2. — The rates structure in **Germany.** (2 000

1939 **623 (.42) & 656 .1 (.42)**
Modern Transport, No. 1075, October 21, p. 5.
Road haulage in wartime. Work of Associated Road operators, concessions obtained for hauliers. (1 200 words.)

1939 **621 .431.72 (.67)**
Modern Transport, No. 1075, October 21, p. 7.
Diesel railcar operation in Rhodesia. Unit with Ganz-Jendrassik engine. (1 500 words & fig.)

1939 **629 .113.4 (.42)**
Modern Transport, No. 1076, October 28, p. 3.
Gas producers and A. E. C. policy. Adoption of Belloy system. (1 400 words & fig.)

1939 **621 .132.5 (.43)**
Modern Transport, No. 1076, October 28, p. 4.
Locomotive design in Germany. An express goods traffic unit. (1 200 words & fig.)

1939 **656 .1 (.42) & 656 .212 .7 (.42)**
Modern Transport, No. 1077, November 4, p. 3.
Equipment for road-rail combined transport, No. 1. — Aid from containers : simplifying their handling. (2 400 words & fig.)

1939 **351 .812 & 656 .23 (.73)**
Modern Transport, No. 1077, November 4, p. 4.
DELANNEY (L.). — **Goods transport by rail and road.** No. 3. — Rates in the **United States.** (1 600 words.)

1939 **623 (.42) & 656 .2 (.42)**
Modern Transport, No. 1077, November 4, p. 5.
Evacuation of air raid casualties. Three Southern Railway trains. (1 500 words & fig.)

1939 **629 .113 & 662**
Modern Transport, No. 1078, November 11, p. 3.
WALTON (J.). — Alternative **fuels** for motor vehicles. (3 000 words & fig.) (To be continued.)

1939 **623 (.42) & 625 .232 (.42)**
Modern Transport, No. 1078, November 11, p. 5.
Ambulance trains for home and overseas. (2 400 words & fig.)

1939 **656 .1 & 656 .261**
Modern Transport, No. 1078, November 11, p. 6.
Equipment for road-rail combined transport. No. 2. — Road vehicles by rail. Dyson system for trailers. (1 500 words & fig.)

1939 **656 .1 & 656 .261**
Modern Transport, No. 1079, November 18, p. 5.
Equipment for **road-rail combined transport. No. 3. — Containers** without cranes. Development of Maquard system. (950 words & fig.) (To be continued.)

Railway Age. (New York.)

1939 **625 .232 (.73) & 625 .235 (.73)**
Railway Age, No. 14, September 30, p. 470.
Low-alloy steel cars built by American Car & Foundry Co. (3 200 words & fig.)

1939 **625 .232 (.73)**
Railway Age, No. 14, September 30, p. 476.
Budd-built **cars of stainless steel.** (3 900 words & fig.)

1939 **625 .232 (.73)**
Railway Age, No. 14, September 30, p. 481.
Pullman-Standard builds **aluminium-alloy cars.** (2 400 words & fig.)

1939 **625 .1 (06 (.73)**
Railway Age, No. 14, September 30, p. 486.
Roadmasters discuss problems at Chicago Meeting (September 21-23). — Part I. — Subjects dealt with : Safety of **track maintenance work; maintenance of curves** for high speeds; the **roadmaster's qualifications** and duties. (7 000 words.)

1939 **621 .132.3 (.73) & 621 .132.5 (.73)**
Railway Age, No. 15, October 7, p. 515.
Union Pacific adds to high-capacity **motive-power fleet.** (2 000 words, tables & fig.)

1939 **625 .1 (06 (.73)**
Railway Age, No. 15, October 7, p. 519.
Roadmasters discuss problems at Chicago meeting (19-21 September 1939). — Abstracts of two papers and 3 Committee reports on : — **Heaving track,** its causes and control; Trends in the **manufacture and maintenance of rail; Anchoring track** to meet present-day conditions; **High-speed trains and track maintenance;** Specialized versus **section gangs.** (7 400 words.)

1939 **385 .1 (.73) & 656 .22 (.73)**
Railway Age, No. 15, Octoher 7, p. 526.
GORMLEY (M. J.). — American Association of Railroads' view of **Railroad's capacity.** (3 600 words & fig.)

1939 **656 .22 (.73)**
Railway Age, No. 16, October 14, p. 551.
Five and a half years of the **streamliners.** (1 600 words.)

1939 **385 .113 (.73) & 656 .22 (.73)**
Railway Age, No. 16, October 14, p. 559.
Statistics prove success of **streamliners.** (4 000 words & fig.)

1939 **656 .22.1 (.73)**
Railway Age, No. 16, October 14, p. 578.
« Speed limit. — ninety miles ! » **New fast trains are operated with safety** and a high on-time percentage. (2 300 words & fig.)

1939 **656 .22 (.73) & 656 .23 (.73)**
Railway Age, No. 16, October 14, p. 580.
Ten million patrons can't be wrong. Brilliant sales campaigns feature **success of new trains** and generally increase passenger traffic. (2 300 words & fig.)

1939 **625 .232 (.73)**
Railway Age, No. 16, October 14, p. 583.
Light weight captures the field. Starting with streamline trains, the new construction materials take over all types of passenger equipment. (3 700 words, fig. & tables.)

1939 **625 .14 (.73) & 656 .222.1**
Railway Age, No. 16, October 14, p. 589.
Faster trains ! Better track ! Shortened sch demand a **stronger structure,** maintained to more ing standards. (2 500 words & fig.)

1939 **625 .13**
Railway Age, No. 17, October 21, p. 615.
Raising long passenger bridge under traffic no task. Pennsylvania devised interesting metho carry out project at Harrisburg, Pa., made necessa electrification. (3 300 words & fig.)

1939 **385 .586**
Railway Age, No. 17, October 21, p. 620.
Baldwin addresses mechanical associations **(tra and coaching supervision).** (3 000 words.)

1939 **(**
Railway Age, No. 17, October 21, p. 622.
New products alter **fire hazards.** (700 words & t

1939 **621 .431.72 (.73) & 621 .335**
Railway Age, No. 17, October 21, p. 625.
Diesel-hydraulic switcher shows flexible chara tics. Hydraulic transmission permits full engine power to be utilized at all speeds. (1 700 words &

1939 **621 .13 (06**
Railway Age, No. 18, October 28, p. 645.
Problems of locomotive operation discussed at cago. Fuel and traveling engineers in heavy pr deal with **train handling, fuel economy,** and **utili of locomotives.** (6 300 words.)

1939 **621 .133 (06**
Railway Age, No. 18, October 28, p. 651.
Master Boiler Makers' Association annual me Twenty-sixth annual meeting at Chicago. Pr included seven addresses and eight technical re (1 700 words.)

1939 **625 .1 (06**
Railway Age, No. 18, October 28, p. 653.
Bridge and building men study many proble Chicago (8 Committee reports and 3 technical add — **Maintaining old masonry** — Elimination of **orders** while making **bridge repairs** — **Deteri concrete,** causes, detection and methods of repa **Pumping equipment** to meet today's requirem (7 000 words & fig.)

1939 **621 .138 (06**
Railway Age, No. 18, October 28, p. 663.
Locomotive maintenance men meet at Chicago October 1939). — Papers presented : The **qualities good-supervisor** — **Maintaining modern powe Thorough inspection important,** etc... (2 700 words

1939 **625 .2 (06**
Railway Age, No. 18, October 28, p. 665.
Car Officers emphasize need for better car cond — Association meeting in Chicago considers m of securing more efficient **utilization and mainte of railway car equipment.** (17-19 October 1939.) words.)

614 .8 (06 (.73) & 656 .25 (.73)
y Age, No. 18, October 28, p. 667.
oads at National Safety Congress. — Notable
's outline ways and means to overcome « tena-
types of accidents. (3 200 words.)

ailway Engineering and Maintenance. (Chicago.)

625 .1 (06 (.73)
y Engineering and Maintenance, October, p. 591.
lmasters unravel many problems at convention
Sept., 1939). Abstracts of papers and Commit-
ports on : — **Safety** can be achieved; **Heaving** — its causes, control and maintenance; Specia-
ersus section gangs; The **maintenance of curves**
h-speed trains; Utilization of **roadway machines**;
ing track to meet present-day conditions; The
aster's **qualifications and duties**. (43 000 words

Railway Magazine. (London.)

623 & 656 .2
ay Magazine, No. 509, November, p. 311.
(Ch. E.). — **Railways and the war** — I. (6 500
& fig.)

lway Mechanical Engineer. (New York.)

621 .335 (.73) & 621 .431.72 (.73)
ay Mechanical Engineer, October, p. 385.
performance with **diesel hydraulic locomotive.**
words & fig.)

625 .215 (.4 + .7)
ay Mechanical Engineer, October, p. 387.
SL-GIESLINGEN (A.). — Trends in **passenger-**
uck design. (2 800 words & fig.)

Railway Signaling. (Chicago.)

656 .258 (.73)
ay Signaling, October, p. 541.
y interlocking on the Southern Pacific. (1 800
& fig.)

625 .162 (.73) & 656 .259 (.73)
ay Signaling, October, p. 544.
nway crossing signals. (1 900 words & fig.)

656 .258 (.73)
ay Signaling, October, p. 548.
LLOY (J. H.). — **Automatic cut-outs** at an auto-
interlocking. (5 700 words & fig.)

656 .258 (.42)
ay Signaling, October, p. 555.
routes in a relay interlocking. (1 300 words &

Railway Gazette. (London.)

623 (.42) & 656 .1 (.42)
ay Gazette, No. 16, October 20, p. 515.
d transport and the war — 2. (4 000 words.)

623 (.42) & 625 .232 (.42)
Railway Gazette, No. 16, October 20, p. 521.
Home ambulance trains. (500 words & fig.)

623 & 656
Railway Gazette, No. 16, October 20, p. 525; No. 17, October 27, p. 557; No. 18, November 3, p. 589 and No. 19, November 10, p. 617.
Transport services and the war. (16 000 words & fig.)

621 .132.3 (.42)
Railway Gazette, No. 17, October 27, p. 545.
General utility locomotives. (2 900 words, tables & fig.)

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Bridge and building men study many problems at Chicago. Part II. (Discuss **glazing, preframing, bridge painting, roof maintenance, building requirements** and **strengthening old bridges.**) (8 100 words & fig.)

1939 621 .431.72 (.73) & 625 .232 (.73)
Railway Age, No. 20, November 11, p. 736.
North Western places **new « 400 » streamliners** in service. Two trains of ten cars each, built by Pullmann-Standard, are hauled by new 4 000-h.p. **Electro-motive diesels.** (3 850 words & fig.)

1939 385 (061.4 & 621 .33 (.73)
Railway Age, No. 20, November 11, p. 742.
Two electrical sections of the A. A. R. get together. Short abstracts of reports and discussion. I. — **Electrical section, Mechanical division :** Illumination of rolling stock. — Motors and control. — Power plants. — Radio and communication systems. — Car electrical equipment. — Automotive and electric rolling stock. — Electric welding. — Locomotive electrical equipment. II. — **Electrical section, Engineering. Division IV,** A. A. R. : Power supply. — Electrolysis. — Overhead transmission line and catenary construction. — Standardization of apparatus and materials. — Electric heating and welding. — Application of motors. — Clearances for third rail and overhead working conductors. — Protective devices and safety rules in electrified territory. — Track and third rail bonds. — Illumination. — Design of indoor and outdoor substations. — High tension cables. — Application of corrosion resisting material to railroad electric construction. (6 250 words.)

1939 621 .133.8 (.73)
Railway Age, No. 20, November 11, p. 747.
Power **reverse gear operating valve.** (500 words & fig.)

1939 313 : 656 .28 (.73)
Railway Age, No. 20, November 11, p. 748.
Accidents in 1938. (1 250 words.)

1939 385 (064 (.73)
Railway Age, No. 20, November 11, p. 749.
Railroads' fair show evaluated. (700 words & fig.)

1939 721 .31 (.73)
Railway Age, No. 20, November 11, p. 751.
Renovated **rest rooms** draw patrons' appreciation. (2 150 words & fig.)

1939 625 .111 (.73) & 625 .162 (.73)
Railway Age, No. 21, November 18, p. 784.
Grade separation on C. R. R. of New Jersey involved difficult **traffic problem.** (4 700 words & fig.)

1939 **656 .212.9 (.73), 656 .225 (.73) & 656 .261 (.73)**

Railway Age, No. 21, November 18, p. 789.

What about **L. C. L. ?** Superintendents consider possibilities of regaining **merchandise traffic** and how it should be handled. (3 600 words & fig.)

1939 **625 .29 (.73) & 656 .29 (.73)**

Railway Age, No. 21, November 18, p. 792.

Handling passenger-train cars at terminals. (2 800 words, tables & fig.)

1939 **625 .232 (.73)**

Railway Age, No. 22, November 25, p. 812.

D. & H. **lightweight coaches** for the « Laurentian ». (2 500 words, tables & fig.)

1939 **385 .2 (.73)**

Railway Age, No. 22, November 25, p. 817.

River haulage not cheap says senator Clyde Reed. (2 000 words.)

1939 **621 .139 (.42) & 625 .27 (.42)**

Railway Age, No. 22, November 25, p. 824.

No frills in P. R. R. Storekeeping. Unnecessary correspondence avoided in **operating regional stores.** — Centralized grain door and grease **reclamation.** (1 500 words & fig.)

1939 **625 .261 (.73)**

Railway Age, No. 22, November 25, p. 826.

Selling railroad freight service. — St. Louis-San Francisco modernizes merchandise service, uses **coordinated rail-highway operation** and promotes **employee campaigns.** (1 400 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1939 **625 .143.2 (.73) & 625 .172 (.73)**

Railway Engineering and Maintenance, Novemb., p. 668.

BRONSON (C. B.). — Where are we heading in **rail manufacture and maintenance ?** (3 700 words & fig.)

1939 **625 .1 (06 (.73)**

Railway Engineering and Maintenance, Novemb., p. 675.

BRIDGE AND BUILDING ASSOCIATION **holds annual Convention** (17-19 October) : Eight Committee reports were discussed : **Maintenance of shop and engine house roofs; Deteriorated concrete,** causes, detection and repairs; **bridge painting problems** resulting from deferred maintenance; **elimination of slow orders in connection with bridge repair and renewal;** use of **preframed treated timber** for replacement purposes; **safeguarding bridge structures; glazing maintenance** in shops and engine houses. — Also individual reports on : **Maintaining old masonry; strengthening old bridges;** meeting today's requirements in **railway structures.** (27 000 words & fig.)

Railway Magazine. (London.)

1939 **656 .251 (.44)**

Railway Magazine, No. 510, December, p. 384.

LASCELLES (T. S.). — **French signal aspects.** (1 950 words & fig.) (To be continued.)

1939 **623 (.42) & 656 .2**

Railway Magazine, No. 510, December, p. 395.

LEE (Ch. E.). — **Railways and the war** – (4 600 words & fig.)

Railway Mechanical Engineer. (New Yor

1939 **621 .133 (06**

Railway Mechanical Engineer, November, p. 43

Constructive reports presented at meeting of M Boiler Makers. (October 17, 18, 19 — 1939). **Appr training, renewal of fireboxes, circulation of w feedwater treatment,** and **welded construction of t cistern** were some of the subjects included in program. (12 800 words & fig.)

1939 **625 .2 (06**

Railway Mechanical Engineer, November, p. 45

Meeting of Car Department Officers. (October 19 — 1939). Well-attended sessions of the assoc at Chicago hear constructive addresses and comm reports on **more efficient utilization and mainte of car equipments.** (8 000 words.)

1939 **621 .13 (06**

Railway Mechanical Engineer, November, p. 46

Locomotive supervisors' meeting (October 17 to 1939). Among the subjects discussed were **braki** high-speed freight and passenger trains, **locom utilization** and **locomotive economy devices.** — aspects of **fuel economy** considered in committe ports. (22 400 words & fig.)

1939 **621 .138 (06**

Railway Mechanical Engineer, November, p. 486

New Association discusses problems of **locom maintenance** (October 17 — 1939). Locomotive de ment supervisors hear papers and talks on **tra supervisors, apprenticeship, heat treating, sched** and **tool selection.** (22 700 words & fig.)

1939 **621 .132.3 (.73) & 621 .132.5**

Railway Mechanical Engineer, November, p. 503

Powerful **high-speed locomotives** for Union Pa (2 700 words & fig.)

Railway Signaling. (Chicago.)

1939 **656 .257**

Railway Signaling, November, p. 595.

St. Louis Municipal **bridge signaling.** (2 400 & fig.)

1939 **625 .162 (.73) & 656 .259**

Railway Signaling, November, p. 601.

Ten **automatic crossing gates** on one street. I lation on Pullman Railroad controlled automatical complicated switching area. **Dwarf signals g train movements** at crossings. (5 000 words & fig

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1939 **656**

Railway Signaling, November, p. 607.

BRUCE (F. C.). — Safety and design of **signa cuits.** (5 200 words & fig.)

1939 **656 .256**

Railway Signaling, November, p. 616.

DICK (M. H.). — **Copper strips in rails** (to e proper functioning of signals). (2 000 words & fig

Mechanical Engineering. (New York.)

625 .28

nical Engineering, No. 12, December, p. 863.
ress in railway **mechanical engineering**, 1938- — Moderate recovery experienced. — Technical ements in **locomotives** and **cars** noted. (9 100 tables & fig.)

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621 .437 (.42), 625 .28 (.42) & 629 .11. (.42)

nical Engineering, No. 12, December, p. 876.
anical problems in British transportation. Abs- of four British papers dealing with airplanes, vehicles, **light-weight railway passenger stock,** erchant-marine ships. (6 600 words, tables & fig.)

African Railways and Harbours Magazine. (Johannesburg..)

621 .132.5 (.68)

African Railways and Harbours Magazine, Oc- ber, p. 1333.
locomotives on the South African Railways. — particulars of the **class 15 F engine.** (1 000 words

---

nnals of the American Academy of Political and Social Science. (Philadelphia.)

33 (06 (.73)

Annals of the American Academy of Political d Social Science, November 1939.
ernment expansion in the economic sphere. A of the increasing **economic functions of govern-** (25 papers — 170 pages.)

The Engineer. (London.)

624 .163 (.42)

ngineer, No. 4376, November 24, p. 518.
new Waterloo **bridge.** (550 words.)

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656 .211.7 (.42) & 656 .213 (.42)

ngineer, No. 4376, November 24, p. 524.
ramp at Larne harbour. (1 250 words & fig.)

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627 & 693

Engineer, No. 4376, November 24, p. 527, and . 4377, December 1, p. 550.
IN (G. S.). — **Concrete** for hydraulic structures. words & fig.)

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621 .433 & 629 .113.4

ngineer, No. 4376, November 24, p. 529.
r cooler for producer gas plants. (700 words

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624 .51 (.71)

ngineer, No. 4377, December 1, p. 534.
s Gate **bridge** at Vancouver. (5 600 words & fig.)

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621 .331 (.42)

ngineer, No. 4377, December 1, p. 540 (No. IV) d No. 4378, December 8, p. 561 (No. V).
ote supervisory control. (Southern Railway's tions.) (6 100 words & fig.) (To be continued.)

1939 **623 (.42) & 625 .42 (.42)**

The Engineer, No. 5377, December 1, p. 542.
Protective works on underground railways. (1 300 words & fig.)

1939 **62 (06 (.42)**

The Engineer, No. 4377, December 1, p. 548.
Technical institutions in war time. (3 900 words.)

1939 **656 .25 (.42)**

The Engineer, No. 4378, December 8, p. 564 and December 15, p. 15.
Modern **Railway Signalling Practice,** No. I and No. II. (7 500 words & fig.) (To be continued.)

The Journal of the Institute of Transport. (London.)

1939 **656 (.42)**

The Journal of the Institute of Transport, No. 1, November 1939, p. 5.
THOMAS (T. E.). — **Tributaries of Transport.** (6 700 words.)

The Locomotive. (London.)

1939 **625 .25**

The Locomotive, No. 567, November 15, p. 301.
The importance of **braking.** (900 words.)

1939 **625 .23**

The Locomotive, No. 567, November 15, p. 302.
Lightweight passenger stock. (900 words.)

1939 **623 (.42) & 625 .232 (.42)**

The Locomotive, No. 567, November 15, p. 306.
Ambulance trains. (1 100 wowrds & fig.)

1939 **621 .132.8 (.493)**

The Locomotive, No. 567, November 15, p. 319.
WIENER (L.). — **Steam carriages,** Belgian State Railways. (2 100 words & fig.)

1939 **625 .25**

The Locomotive, No. 567, November 15, p. 322, and December 15, p. 350.
Some aspects of **braking.** (4 050 words & fig.)

1939 **621 .133.8**

The Locomotive, No. 567, November 15, p. 325.
A new **automatic drifting valve.** (950 words & fig.)

1939 **625 .23 & 625 .28**

The Locomotive, No. 568, December 15, p. 334.
High-speed lightweight trains. (3 000 words.) (To be concluded.)

1939 **621 .137 & 621 .138**

The Locomotive, No. 568, December 15, p. 342.
PHILLIPSON (E. A.). — The steam locomotive in traffic. IV. **Locomotive depot equipment.** (950 words & fig.) (To be continued.)

1939 **621 .132.1 (.42)**

The Locomotive, No. 568, December 15, p. 344.
MORRIS (O. J.). — **Standardising** Southern Railway **Locomotives.** Central Section (12). The « Small Vulcans », 0-6-0, Class C 2. (2 100 words & fig.) (To be continued.)

1939 **625 .232 (.42)**
The Locomotive, No. 568, December 15, p. 353.
New **passenger coaches,** Central Uruguay Railway. (1 000 words & fig.)

1939 **625 .1 (.492)**
The Locomotive, No. 568, December 15, p. 354.
DERENS (L.). — The **high-level belt railway** and the new **stations** in Amsterdam. (1 800 words & fig.)

The Oil Engine. (London.)

1939 **621 .43**
The Oil Engine, December, p. 248.
INGHAM (E.). — **Wear and tear of engine pistons.** Guides to prudent operation which minimize the risk of breakdown. (2 800 words & fig.)

The Railway Gazette. (London.)

1939 **656 .255 (.54)**
The Railway Gazette, November 17, p. 636.
Sub-token single-line working on the Madras & Southern Mahratta Railway. An arrangement adopted to facilitate traffic working and permit railcars to pass at a siding midway in a token section. (750 words & fig.)

1939 **623 & 656 .1**
The Railway Gazette, November 17, p. 639.
Road transport and the war — 3. The position of the **German motor roads.** — **Street and vehicle lighting.** — **Fuel.** (2 000 words.)

1939 **629 .113.4 & 662**
The Railway Gazette, November 17, p. 641.
REED (Brian). — **Producer-gas for commercial vehicles.** An account of the taxation and Road Traffic Act regulations, together with descriptions of the plants available and the results obtained in Great Britain. (1 600 words & fig.) (To be continued.)

1939 **625 .111 (.68) & 625 .162 (.68)**
The Railway Gazette, November 17, p. 644.
Level crossing elimination in South Africa. Notable **station reconstruction** on the Witwatersrand. (550 words & fig.)

1939 **388 (.42) & 625 .111 (.42)**
The Railway Gazette, November 24, p. 668.
Bakerloo trains to Stanmore. **New through services** provided between the Bakerloo and Metropolitan lines of the London Passenger Transport Board have necessitated heavy and intricate **engineering works.** (4 200 words & fig.)

1939 **623 (.42) & 625 .232 (.42)**
The Railway Gazette, November 24, p. 676.
Casualty evacuation trains. Supplementary details of the 30 trains provided at the request of the Ministry of Health, and now standing by in various parts of Great Britain. (1 750 words & fig.)

1939 **623 & 656**
The Railway Gazette, November 17, p. 649 (12); November 24, p. 681 (13); December 1, p. 714 (14); December 8, p. 746 (15), and December 15, p. 781 (16).
Transport services and the war. (30 900 words & fig.)

1939 **385. (**
The Railway Gazette, December 1, p. 701.
Association of American Railroads. Work o seven divisions forming the Operation & Mainte Department. (1 300 words.)

1939 **625 .1**
The Railway Gazette, December 1, p. 702.
Lateral forces on rails. Use of **piezo-electric to measure forces** between locomotives and tra France. (1 600 words, tables & fig.)

1939 **621 .132.1**
The Railway Gazette, December 1, p. 704.
New **locomotives** for India. (1 700 words & fig.

1939 **625 .142.4**
The Railway Gazette, December 8, p. 733.
Reinforced concrete sleepers in Netherland (240 words & fig.)

1939 **623 (.42) & 625 .232**
The Railway Gazette, December 8, p. 735.
Military ambulance trains. (900 words & fig.)

1939 **385 (091 (**
The Railway Gazette, December 8, p. 736.
The **Finnish Railways.** (1 400 words & fig.)

1939 **625 .258 (.44) & 656 .212.6**
The Railway Gazette, December 15, p. 765.
Automatic control of wagons in marshalling y New system of working introduced in France. (words & fig.)

1939 **625 .162**
The Railway Gazette, December 15, p. 769.
Occupation level crossings in Great Britain. — Co Mount's comprehensive review of the legal and tical aspects, appended to his report on the H accident. (4 400 words.)

1939 **621 .131.3 (.44) & 621 .132.3**
The Railway Gazette, December 15, p. 778.
Further remarkable **locomotive trials** in Fr Chapelon rebuilt **4-8-0 tested** on high-speed trains. words & fig.)

1939 **656 .283**
The Railway Gazette, December 15, p. 786.
Ministry of transport **accident report.** Cross I Crossing, Hilgay, L. N. E. R.; June 1, 1939. (2 400 w & fig.)

1939 **351 .81 (.42) & 623**
The Railway Gazette, December 15, p. 789.
War organisation of Ministry of Transport. (words.)

1939 **621 .431.72 & 656 .2**
Diesel Railway Traction, p. 174, supplt. to the Rail Gazette, November 24.
KOFFMANN (J. L.). — **Railcar acceleration mechanical transmission.** An examination of som the problems involved. (1 550 words & fig.)

621 .13 (.489) & 621 .431.72 (.489)
Railway Traction, p. 176, supplt. to the Railway zette, November 24.
l and steam traction on Danish State Railways. ords.)

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621 .431.72 (.42)
Railway Traction, p. 177, supplt. to the Railway zette, November 24.
ıt small diesel locomotives. (Fowler-Sanders- r-Drewry.) (750 words & fig.)

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621 .436
Railway Traction, p. 178, supplt. to the Railway zette, November 24.
types of **oil engines.** Some recently-introduced which have possibilities **for railcar and loco- applications** (Perkins, Ruston, Blackstone- (1 150 words & fig.)

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621 .431.72
Railway Traction, p. 179, supplt. to the Railway zette, November 24.
ouilt diesel railcar (Luxemburg). — Interesting **transmission** equipment installed in narrow- vehicle. (1 600 words & fig.)

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621 .431.72 (.73) & 656 .222.1 (.73)
Railway Traction, p. 181, supplt. to the Railway zette, November 24.
l train operation on the Santa Fe. — A brief of the express trains over medium and long e routes hauled by diesel locomotives. (1 650 & fig.)

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621 .431.72 & 662
Railway Traction, p. 184, supplt. to the Railway zette, November 24.
RD (G. W.). — **Fuel storage for diesel rail ve-** (1 800 words & fig.)

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621 .335 (.494)
Railway Traction, p. 136, supplt. to the Rail- y Gazette, December 8.
e-phase locomotive for mountain line. (2 800 & fig.)

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621 .335 (.47)
Railway Traction, p. 139, supplt. to the Rail- y Gazette, December 8.
tension 50-cycle locomotive. Shop trials of the . R. experimental unit have now been finished. words & fig.)

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621 .336
Railway Traction, p. 142, supplt. to the Rail- y Gazette, December 8.
MPION (D. L.). — **Overhead contact line or third rail ?** A meteorological consideration of the problem. (650 words & fig.)

Transit Journal. (New York.)

1939 **385 (071.3 (.73) & 625 .26 (.73)**
Transit Journal, No. 12, November, p. 444.
Milwaukee effectively integrates **inspection and maintenance of 124 trolley buses** with 240 **gas buses** and 600 **street cars** by careful education of shop workers. **Training for trolley bus maintenance.** (2 100 words & fig.)

University of Illinois Bulletin. (Urbana.)

1939 **62 (01 & 669 .1**
University of Illinois Bulletin, No. 5, September 26.
SMITH (J. O.). — The effect of range of stress on the torsional fatigue strength of steel. (8 500 words, tables & fig.)

1939 **62 (01 & 624 .2**
University of Illinois Bulletin, No. 6, October 3.
WILSON (W. M.) and COOMBE (J. V.). — Fatigue tests of connection angles. (5 500 words, tables & fig.)

1939 **662**
University of Illinois Bulletin, No. 7, October 10.
A series of 19 papers presented at the fifth short course in **coal utilization,** held at the University of Illinois, May 23-25, 1939. (65 000 words, tables & fig.)

1939 **62 (01**
University of Illinois Bulletin, No. 10, October 31.
MOORE (H. F.). — **Stress, strain,** and **structural damage.** (Reprinted from the Proceedings of the American Society for Testing Materials, Vol. 39, Part II, 1939). (13 000 words & fig.)

In Italian.

L'Ingegnere. (Roma.)

1939 **656 .136**
L'Ingegnere, n° 11, 15 novembre, p. 943.
MARCHISIO (M.). — Caratteristiche, tendenze e sviluppi della **trazione filoviaria.** (6 500 parole & fig.)

Rivista tecnica delle ferrovie italiane. (Roma.)

1939 **385. (09.3 (.45)**
Rivista tecnica delle ferrovie italiane, n° 5, 15 novembre, p. 257.
VELANI (L.). — Un secolo di **sviluppo delle ferrovie italiane.** Il conferenza generale tenuta nella riunione generale di Pisa (ottobre 1939 — XVII) della Società per il progresso delle Scienze. (9 500 parole.)

1939 **621 .132.8 (.45)**
Rivista tecnica delle ferrovie italiane, n° 5, 15 novembre, p. 275.
BAJOCCHI (U.). — **Confronto sperimentale tra due locomotive** tipo 670 di cui una trasformata secondo il **sistema « Franco »**. (5 000 parole & fig.)

1939 **385. (072 (.45)**
Rivista tecnica delle ferrovie italiane, n° 5, 15 novembre, p. 290.
CARUCCI (E.). — **Sulla determinazione sperimentale del coefficiente medio unitario di dispersione** delle celle termostatiche della camera termica dell'Istituto Sperimentale delle Comunicazioni in Roma. (2 500 parole & fig.)

In Dutch.

De Ingenieur. (Den Haag.)

1939 **621 .431.72**
De Ingenieur, Nr. 49, 8 December, p. V. 87.
OSINGA (J. R.). — **Motortractie voor spoor- en tramwegen.** (7 800 woorden & fig.)

1939 **621 .13 (09**
De Ingenieur, Nr. 50, 15 December, p. V. 99.
LABRIJN (P.). — De **ontwikkeling van de stoomlocomotief** in den loop der tijden. (8 700 woorden, tab. & fig.)

1939 **656 .211 (.492) & 725 .31 (.492)**
De Ingenieur, Nr. 51, 22 December, p. B. 209.
SCHELLING (H. G. J.). — **Nieuwe stations** te Amsterdam. (7 900 woorden & fig.)

1939 **656 .21 (.492)**
De Ingenieur, Nr. 51, 22 December, p. V. 111.
BERDENIS VAN BERLEKOM (W. J.). — Ontwikkeling en gebruik der **nieuwe spoorbanen** van Amsterdam-Oost. (3 900 woorden & fig.)

Spoor- en Tramwegen. (Utrecht.)

1939 **625 .18 (.492)**
Spoor- en Tramwegen, Nr. 24, 25 November, p. 637.
VAN DER PLOEG (J. Ae.). — De **werkplaatsen en magazijnen** van den Dienst van Weg en Werken der Nederlandsche Spoorwegen. (1 150 woorden & fig.)

1939 **385. (07**
Spoor- en Tramwegen, Nr. 24, 25 November,
HALBERSTADT (H. A. C.). — **School voor H**
bij den Dienst van het Vervoer. (1 150 woorden &

1939 **656 .222.**
Spoor- en Tramwegen, Nr. 25, 9 December, p. 6
Verhooging van de rijsnelheid van personen
in de voornaamste landen van Europa van
1934-1 Juli 1938, haar oorzaken en gevolgen.
woorden & tab.)

1939 **385 .57**
Spoor- en Tramwegen, Nr. 25, 9 December, p. 6
LUNING PRAK (J.). — **Psychologisch onde**
(2 900 woorden & fig.) (Slot volgt.)

1939 **3**
Spoor- en Tramwegen, Nr. 26, 23 December, p.
LUNING PRAK (J.). — **Psychologisch onde**
II. (Slot.) (2 300 woorden.)

1939 **385. (09**
Spoor- en Tramwegen, Nr. 26, 23 December, p.
VAN SETTEN (D.). — De **Spoorwegen** in Fi
(1 800 woorden & fig.)

1939 **621 .33**
Spoor- en Tramwegen, Nr. 26, 23 December, p.
De **electrificatieplannen** der Nederlandsche
wegen. (1 600 woorden, taf. & fig.)

In Portuguese.

Técnica. (Lisboa.)

1939 **6**
Técnica, n° 106, Dezembro, p. 474.
CARDOSO (E.). — **Cálculo dos sistemas hip**
ticos com o auxílio de modêlos reduzidos. (3 50
lavras & fig.)

1940 **62**
Técnica, n° 107, Janeiro, p. 550.
JOSÉ FARIA DA FONSECA SANTOS &
OLAIA LOPES MONTOYA. — **A traçagem construçâo metálica.** (2 500 palavras & fig.)

M. Weissenbruch Co., Ltd., Printer of the King, 49, rue du Poinçon, Bruxelles.

MONTHLY BIBLIOGRAPHY OF RAILWAYS [1].

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eneral Secretary of the Permanent Commission of the International Railway Congress Association.

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. 385. (02]

I. — BOOKS.

In French.

621 .436

(O.).
élémentaire du moteur Diesel, fixe, marin, obiles et de locomotives. Fonctionnement. Con- n. Entretien. Traduit de l'anglais par Ch. .
Dunod, 92, rue Bonaparte. XXI-650 pages 25 cm.), avec 53 figures. (Prix : relié, 205 fr.; 185 fr.)

621 .392

udure par points des alliages légers.
(17e), La Soudure électrique, 20, rue Toulouse- . Une brochure de 40 pages, avec figures.

In German.

624 .2

ER (A.).
durchlaufende Balken auf elastisch drehbaren stisch senkbaren Stützen.
h, Gebr. Leeman. 1 Band, 170 Seiten mit 77 Bil- 5 Zahlentafeln und 8 Tafeln.

385 (.43)

scher Reichsbahn-Kalender 1940. 14. Jahrgang. gegeben vom Pressedienst des Reichsverkehrs- riums.
ig, Konkordia-Verlag Reinhold Rudolph. (Preis : RM. Für deutsche Eisenbahner Vorzugspreis M.)

69. (02

LOGEL (A.).
nenformeln.
n, W. Ernst & Sohn. (Preis : geh. 23 RM., RM.)

662

TA (F.).
stoffe für Verbrennungsmotoren.
, J. Springer. 346 S. m. 70 Bild. u. 32 Tab. : 19.80 RM.)

656 .237 (.43)

nz- und Rechnungswesen der Deutschen Reichs- Herausgegeben vom Verband Deutscher Eisen- achschulen. 2. Auflage.
n, Verlag Beamtenpresse G.m.b.H., Berlin S. W. eis : 2.85 RM.)

In English.

1939 621 .13 (093 (.42)

DENDY MARSHALL (C. F.).
Early British Locomotives. A supplement to the Author's « Two essays in early locomotive history ».
London, The Locomotive Publishing Co. Ltd. (Price : 12 s. 6 d.)

1939 385 .1

CUNNINGHAM (W. J.).
The present railroad crisis.
Philadelphia (Pa.), University of Pennsylvania Press. 84 pages (8 1/2 in. × 5 1/2 in.). Bound in cloth. (Price : $ 1.00.)

1940 621 .116

WEBSTER (J.).
Gas charts for steam boilers.
Manchester, Emmott and Company, Limited. (Price : 1 s. net.)

1939-1940 385 .1 (.73)

American Railroads : The thirteenth annual debate. Handbook, 1939-1940. Vols. I and II. Edited by Bower Aly.
Missouri (U. S. A.), Lucas Brothers, Publishers, Columbia (8 1/2 in. × 5 3/4 in.), 220 pp. Paper covers. [Price : $ 0.85 (single volume), $ 1.60 (two volumes) net.]

1939 621 .137.1

MOHAMMED FAISY.
The Locomotive, its operation and maintenance. — Directions for drivers and firemen (in arabic).
Cairo, Egyptian State Railways Press. 246 pp. (4 3/4 in. × 6 1/2 in.). Illustrated. (No price stated.)

1939 351 .81 (.73)

MOHUNDRO (O. L.).
Notes on Interstate Commerce Law Practice and Procedure.
Washington (D. C.), Guthrie Lithograph Company. 200 mimeographed pages (9 3/4 in. × 8 1/2 in.). Bound in paper. (No price stated.)

1939 621 .1 (093

THURSTON (R. H.).
A history of the growth of the steam engine. Centennial edition.
Ithaca (N. Y.), Cornell University Press. (Price : $ 3.)

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1939 **385 (.83)**

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1939 **385 .113 (.71)**

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1939 **665 .882**

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1939 **629. (13**

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1940 **625 .144 (.43)**

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1940 **625 .142.2 (.73) & 691 (.73)**

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1939 **624 .61**

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1939 **621 .13 (.438)**

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LÜBSEN (W.). — Die **Lokomotiven** der vormals **Polnischen** Staatsbahnen. (3 000 Wörter & Abb.)

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FELBER (E.). — Die neue **Stellwerkanlage** auf dem **Züricher** Hauptbahnhof. (2 500 Wörter & Abb.)

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1939 **62. (01 & 621 .392**
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1939 **625 .215 & 621 .392**
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TASCHINGER (O.). — Festigkeitsversuche mit **geschweissten Drehgestellen.** (1 350 Wörter & Abb.)

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1940 **621 .32.**
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1939 **625 .152**
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1939 **385 .57 (.**
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Report of Committee 10 : **Signals and interloc** — Principal activities of the Signal Section, A A R synopsis (adopted specifications, designs and princ of signaling practice). (1 200 words.)

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1939 **725 .3 (**
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Report of Committee 6 : **Buildings.** — Prop

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613 (.73) & 725 .33 (.73)

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621 .138 (.73), 625 .26 (.73) & 656 .21 (.73)

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385 .5 (.73)

n, Amer. Ry. Engin. Assoc., No. 414, Dec., p. 291. rt of Committee 22 : **Economics of railway labor.** — Analysis of operations of railways that have d progress in the reduction of maintenance of abor; effect of modern equipment and machines idge gang organization and efficiency; labor nics through revision of operating and maintenance rules. — Etc. (7 000 words.)

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625 .25

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625 .1 (.493)

ngineer, No. 4380, December 22, p. 622.
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625 .23 & 625 .28

Engineer, No. 4382, January 5, p. 3.
motives and trains in 1939. (3 100 words & fig.)

624, 625 .13 & 625 .7

ngineer, No. 4382, January 5, p. 21 and January . p. 30.
ds, bridges and tunnels in 1939. No. I and No. II. words & fig.)

621 .431.72

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engined rail traction in 1939. No. I. (3 800 words (To be continued.)

Engineering. (London.)

1940 **624 .7 (.489)**

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The **Storstrom and Masnedsund bridges,** Denmark. (3 900 words & fig.)

1940 **621 .392**

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HAIGH (B. P.). — **Electric welding** as an integral part of structural design. (8 100 words & fig.) (To be continued.)

1940 **0 (.42)**

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1940 **621 .338 (.45)**

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Recent **developments on the Italian State Railways.** (1 400 words & fig.)

Engineering News-Record. (New York.)

1939 **624 (0 (.73)**

Engineering News-Record, No. 11, September 14, p. 89.
Maintenance experience on 120 bridges. (1 800 words & fig.)

1939 **624 .1 (.73) & 627 (.73)**

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Wharf gets 600 **new piles through old deck.** (2 000 words & fig.)

1939 **625 .13 (.73)**

Engineering News-Record, No. 23, December 7, p. 75.
HARSCH (E.). — **Long bridge raised** by unique procedure. (3 100 words & fig.)

1939 **624 .1 (.73) & 625 .42 (.73)**

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PECK (R. B.). — **Soil tests** check Chicago **subway work.** (1 500 words & fig.)

1939 **624 .51 (.73)**

Engineering News-Record, No. 23, December 7, p. 91.
JONES (J.). — **Welded cable saddles** for Tacoma Narrows **Bridge.** (1 100 words & fig.)

1939 **624 (.73) & 698 (.73)**

Engineering News-Record, No. 23, December 7, p. 92.
Paint maintenance problem on Golden Gate **Bridge.** (700 words.)

1939 **624 .1 (.71)**

Engineering News-Record, No. 25, December 21, p. 48.
Steel pile piers for railroad bridges. (950 words.)

Journal of the Institution of Civil Engineers. (London.)

1940 **624 (.42)**

Journal of the Institution of Civil Engineers, No. 3, January, p. 237.
KURSBATT (I.). — The Kidlington **(railway and canal) bridges.** (5 200 words & fig.)

Journal and Proceedings, The Institution of Mechanical Engineers. (London.)

1939 **625 .23**

Proceedings, The Inst. of Mech. Eng., No. 2, December, p. 81.

Lightweight passenger rolling stock. Communications intended as contributions from the English side to the joint discussion in New York (cancelled owing to the outbreak of war) on the papers by Mr. STANIER, Mr. OTTAWAY and Mr. GOUGE (pp. 13-79). (2 000 words.)

1939 **625 .23, 625 .28 & 656 .222.1**

Proceedings, The Inst. of Mech. Eng., No. 2, December, p. 97.

RIPLEY (C. T.). — **High-speed lightweight trains.** (9 400 words, tables & fig.)

The Locomotive. (London.)

1940 **621 .392 & 621 .138.5**

The Locomotive, No. 569, January 15, p. 11.

BRETT (C. W.). — **Repair of rolling stock by fusive methods.** (2 200 words & fig.)

1940 **621 .431.72**

The Locomotive, No. 569, January 15, p. 17.

Diesel railcars in Luxemburg. (1 200 words & fig.)

Modern Transport. (London.)

1939 **385 .3 (.42)**

Modern Transport, No. 1083, December 16, p. 2.

Compensating the railways for State control. (1 400 words.)

1939 **385 .3 (.42)**

Modern Transport, No. 1083, December 16, p. 3.

Transport and the war. Minister on **control methods.** (1 900 words.)

1939 **621 .132.3 (.73) & 625 .232 (.73)**

Modern Transport, No. 1083, December 16, p. 7.

Streamlined luxury train for New York Central. (1 000 words & fig.)

1939 **623 (.42) & 625 .232 (.42)**

Modern Transport, No. 1084, December 23, p. 5.

Casualty evacuation trains. Use of G. W. R. milk vans. (600 words & fig.)

1939 **656 .1 & 656 .261**

Modern Transport, No. 1085, December 30, p. 5.

Equipment for **road-rail combined transport.** No. 6. — **Container handling device.** Interesting Dutch system. (600 words & fig.)

1940 **656 (.492)**

Modern Transport, No. 1086, January 6, p. 3.

HONDELINK (E. R.). — **Transport problems in Holland.** Railways, Inland waterways and Roads. (2 100 words & fig.)

1940 **625 .23 (.42)**

Modern Transport, No. 1087, January 13, p. 3.

STANIER (W. A.). — **Lightweight passenger rolling stock.** Developments in Great Britain. (2 200 words.)

The Oil Engine. (London.)

1940 **621 .431.72**

The Oil Engine, No. 81, Mid-January, p. 282.

MANN (Chas. F. A.). — Two new 2 000 b.h.p. **engined trains.** (450 words & fig.)

1940 **621 .431.72**

The Oil Engine, No. 81, Mid-January, p. 288.

New **railcars** for the G. W. R. First examp 20 chassis, each with two 105 b.h.p. engines on type. (800 words & fig.)

Railway Age. (New York.)

1939 **625 .143.1 & 62**

Railway Age, No. 10, September 2, p. 336.

Heavier rail — Its effect on **track labor costs.** words, tables & fig.)

1939 **625 .231**

Railway Age, No. 10, September 2, p. 340.

Canadian National **mail and all-steel baggage** (1 300 words & fig.)

1939 **385 .114 (.73) & 656 .2**

Railway Age, No. 10, September 2, p. 347.

BUNNELL (E. H.). — Keeping the variables iable. How the accounting department can give ating men the **information needed to help hold penses in line with traffic volume.** (1 550 words &

1939 **623 (.42) & 656 .2**

Railway Age, No. 23, December 2, p. 843.

SHERRINGTON (C. E. R.). — **British railway war.** (4 200 words & fig.)

1939 **62 (01 (.73) & 625 .246**

Railway Age, No. 23, December 2, p. 843.

Service life of **Cor-ten steel in hopper cars.** (words & fig.)

1939 **625 .123**

Railway Age, No. 24, December 9, p. 882.

Track depression imposed severe **drainage** prob (Southern Railway, U. S. A.). (4 000 words & fig.)

1939 **621 .132.8**

Railway Age, No. 25, December 16, p. 918.

Southern Pacific buys twelve **2-8-8-4 articul coal-burning locomotives** for heavy passenger freight service (built by Lima). (3 200 words &

1939 **624 .62**

Railway Age, No. 25, December 16, p. 923.

DOYNE (M. H.). — St. Louis Municipal **bridge highway deck and railroad deck** is ready for (2 500 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1939 **625 .123**

Railway Engineering and Maintenance, Decemb., p.

COTTON (H. E.). — **Stabilizing the roadbed** thr subdrainage. (3 600 words & fig.)

1939 **385 .587 (.73) & 625 .17**

Railway Engineering and Maintenance, Decemb., p.

Scheduling work equipment. What is good practi (1 700 words, tab. & fig.)

693

Engineering and Maintenance, Decemb., p. 759.
[ARD (J. F.). — How permanent is **masonry** ?
words & fig.)

693 & 698

Engineering and Maintenance, Decemb., p. 761.
RGE (J. P. St.). — **Painting concrete surfaces.**
words.)

625 .17

Engineering and Maintenance, Decemb., p. 762.
ES (G. S.). — **How to remove a tie** ? (1 500

625 .14 (01 & 625 .172

Engineering and Maintenance, Sept., p. 518.
creepage. — It can be controlled. (4 400 words

625 .122 (.73)

Engineering and Maintenance, Sept., p. 522.
slides with drainage and cinders. (2 800 words

Railway Gazette. (London.)

625 .143.3 (.42)

ilway Gazette, December 22, p. 805.
ERS (R.). — Weights of rails. Methods of
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ords & fig.)

625 .23 (.42)

ilway Gazette, December 22, p. 806.
weight passenger rolling stock. (1 700 words

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1940 **625 .143**

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American studies of **steel rails.** (1 500 words.)

1940 **621 .132.8**

Engineer, No. 4387, February 9, p. 127.

COBLE (Howard). — Large American **Mallet motives.** No. I. (2 500 words, 2 tables & fig.)

Engineering. (London.)

1940 **624 .7 (.**

Engineering, No. 3862, January 19, p. 53.

The Storström and Masnedsund **bridges,** Denn (4 000 words & fig.)

1940 **624 .1 & 72**

Engineering, No. 3862, January 19, p. 57.

COOLING (L. F.) and GOLDER (H. Q.). — Port apparatus for **compression tests on clay soils.** (2 words.)

1940 **621 .335 (**

Engineering, No. 3863, January 26, p. 85.

550-H.P. electric **battery shunting locomotive.** (2 words & fig.)

1940 **621**

Engineering, No. 3863, January 26, p. 102.

Estimating boiler thermal efficiency. (3 000 w & fig.)

1940 **621 .335 (.**

Engineering, No. 3864, February 2, p. 105.

12 000-H.P. **electric locomotive** for the St. Gott Railway, Switzerland. (3 000 words & fig.)

) 621 .431.72 (.82)
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YTON (D.). — The influence of various lubri- on the seizure characteristics of hard steel and . (4 500 words & fig.)

Engineering News-Record. (New York.)

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) 625 .7 (.73)
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York : 330, West 42nd street. (Price : 25 c.)

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) 621 .431.72 (.4 + 7)
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WELL (F. T.). — Developments in the applica- the internal combustion engine to railway trac- n Europe and North America. (9 500 words, s & fig.)

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DGER (A. H.). — The examination and tests led parts for steam power plant. (20 000 words, es & fig.)

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lings, Inst. of Mech. Engineers, January, p. 289.
VBERRY (C. W.). — An investigation into the nce and causes of locomotive tyre failures. words, 3 tables & fig.)

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SON (William Storey). — Advances in construc- ethods and equipment (Chelsea Bridge, Wands- Bridge, the Baghdad bridges, etc.). (7 500 words)

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621 .132.3 (.931) & 621 .132.5 (.931)
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1940 621 .338 (.42)
Locomotive, R. C. & W. R., February, p. 34.
L. M. S. R. new stock for the Liverpool and Southport electrified lines. (900 words & fig.)

1940 621 .133.7 & 621 .138
Locomotive, R. C. & W. R., February, p. 40.
PHILLIPPSON (E. A.). — The steam locomotive in traffic. — V. Water supplies and treatment. Boiler washing. (To be continued.) (1 800 words & fig.)

1940 621 .13 (0, 625 .1 & 656 .22
Locomotive, R. C. & W. R., February, p. 40.
Some aspects of railway progress as they affect the locomotive department (continued from page 24, and to be continued). (2 600 words & fig.)

Mechanical Engineering. (New York.)

1940 625 .2 (0
Mechanical Engineering, No. 1, January, p. 18.
ELLIS (D. S.). — Railway-car engineering. (2 400 words.)

Modern Transport. (London.)

1940 656 .1 & 656 .261
Modern Transport, No. 1088, January 20, p. 4 and No. 1090, February 3, p. 9.
Equipment for road-rail combined transport. No. 7 and No. 8. Transferable motor vehicles. Replacement of U. S. A. electric trains. (3 500 words & fig.) (To be continued.)

1940 621 .133.3
Modern Transport, No. 1089, January 27, p. 3.
Value of locomotive superheating. (1 500 words & fig.)

1940 656 .235 (.42)
Modern Transport, No. 1089, January 27, p. 7.
Traders and agreed charges. (1 800 words.)

1940 621 .338 (.42)
Modern Transport, No. 1090, February 3, p. 3.
New rolling stock for L. M. S. electrified services. (2 300 words & fig.)

1940 621 .431.72 (.54)
Modern Transport, No. 1091, February 10, p. 3.
Diesel mechanical (Drewry) railcars for H. E. H. the Nizam's State Railway (single or multiple-unit operation. (2 600 words & fig.)

1940 621 .431.72 (.42)
Modern Transport, No. 1091, February 10, p. 10.
Great Western Railway diesel railcars. New construction and overhauls. Employment of A. E. C. units. (2 000 words & fig.)

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1940 621 .431.72 (.54)
Oil Engine, February, p. 296.
New rolling stock for India. — Four 178 b.h.p. 84 seater solo or multiple railcars with bogie-mounted power plant (Nizam's State Rys.). (900 words & fig.)

Proceedings, American Society of Civil Engineers. (New York.)

1940 **62 (01, 624 & 69**

Proceedings American Society of Civil Engineers, No. 1, January, p. 31.

MOISSEFF (Leon S.) & LIENHARD (Fred). — Theory of **elasticity** applied to **structural design.** (6 000 words, tables & fig.)

Railway Age. (New York.)

1939 **621 .335 (.73) & 621 .431.72 (.73)**

Railway Age, No. 27, December 30, p. 992.

Baldwin builds 1,000 and 660-H.P. **diesel-electric switchers.** (2 400 words & fig.)

1939 **656 .254 (.73) & 656 .256.3 (.73)**

Railway Age, No. 27, December 30, p. 996.

Centralized traffic control solves problem on the Norfolk & Western. (2 000 words & fig.)

1939 **656 .231. (.73)**

Railway Age, No. 27, December 30, p. 999.

EASTMAN (J. B.). — The **adjustment of rates between competing forms of transport.** (3 500 words & fig.)

1939 **725 .33 (.73)**

Railway Age, No. 27, December 30, p. 1002.

What **water treatment** has done for the Illinois Central. (3 600 words & fig.)

1940 **625 .26 (.73) & 725 .33 (.73)**

Railway Age, No. 2, January 13, p. 122.

Chicago & Eastern Illinois builds modern **coach shops.** (2 900 words ä fig.)

1940 **385 (03 (.73)**

Railway Age, No. 2, January 13, p. 126.

Annual **Report of the Interstate Commerce Commission** (neither current traffic level nor pending legislation will solve **transport problems;** reiterate call for action to eliminate **waste; bearing of war on U. S. transportation**). (2 700 words.)

1940 **625 .243**

Railway Age, No. 2, January 13, p. 135.

Denver & Rio Grande Western **automobile-box cars designed for dual service** (automobiles or grain, etc.). (1 600 words & fig.)

1940 **621 .133.7 (.73) & 725 .33 (.73)**

Railway Age, No. 3, January 20, p. 160.

Water Service Men fight **drought** on many fronts. **Emergency measures.** (3 000 words & fig.)

1940 **621 .118 (.73) & 656 .284 (.73)**

Railway Age, No. 3, January 20, p. 163.

Annual **report of Locomotive Inspection Bureau.** Number of locomotives found defective decreased in 1939. (2 000 words, 3 tables & fig.)

1940 **621 .335 (.725) & 621 .431.72 (.725)**

Railway Age, No. 3, January 20, p. 169.

PERKINSON (T. F.). — New Lines in Mexico use **diesel-electric locomotives.** (700 words & fig.)

1940 **625 .111 (.73)**

Railway Age, No. 4, January 27, p. 202.

Rock Island completes its « Samson of the Cimarron » (8-mile **cut-off** involving three-tier **fills** and a 1 2 **river bridge**). (5 000 words & fig.)

1940 **385**

Railway Age, No. 4, January 27, p. 208.

GURLEY (F. G.). — **New technologies in tran** (how railroads have utilized the chemist, metallu inventor and engineer in providing improved equip and service. (5 200 words.)

1940 **62**

Railway Age, No. 4, January 27, p. 212.

Electricity in railroad service (Short abstract papers dealing with railroad subjects, presented a 1940 Winter Convention of the American Institut Electrical Engineers. (3 500 words.)

1940 **629 .113 (.71 + .73) & 656 (.71 +**

Railway Age, No. 4, January 27, p. 215.

14 000 **trucks worked by the railway-owned comp** in U. S. A. and Canada. Description. Operation maintenance. (4 500 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1940 **313 : 625 .144.4 (**

Ry. Engineering and Maintenance, January, p. 19

Railways spent $ 6 000 000 for **work equipmen** 1939. (2 400 words, tables & fig.)

1940 **624 (.73) & 725 .3 (**

Ry. Engineering and Maintenace, January, p. 25.

HAWK (A. T.). — Meeting to day's **requirem in railway structures.** (Report presented at the Convention of the American Bridge and Building A ciation.) (2 800 words & fig.)

1940 **656 .281 (**

Ry. Engineering and Maintenance, January, p 28.

Streamliner (City of San Francisco) **derailment result of sabotage.** (2 300 words & fig.)

Railway Gazette. (London.)

1940 **623 (.42) & 625 .28 (**

Railway Gazette, No. 3, January 19, p. 83.

British rolling stock for service overseas. Detail the 240 **locomotives** and 10 000 **covered wagons** ord by the Ministry of Supply **for use with the Br expeditionary force.** (1 100 words & fig.)

1940 **625 .173 (.42) & 665 .882 (**

Railway Gazette, No. 3, January 19, p. 88.

Welding trackwork by the oxy-acetylene pro L. M. S. R. (2 400 words & fig.)

1940 **621 .138.5 (.42) & 621 .9 (**

Railway Gazette, No. 3, January 19, p. 92.

New **machine tools** at Doncaster Works. (1 250 w & fig.)

1940 **385 (06 (**

Railway Gazette, No. 4, January 26, p. 113.

The Railway Companies' Association. An accoun organisation of British railways. (2 700 words.)

385 (093 (.493)
Gazette, No. 4, January 26, p. 115, and No. 5, uary 2, p. 145.
ER (L.). — The **Nord-Belge system.** (4 000 fig.)

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625 .245 (.43)
Gazette, No. 4, January 26, p. 118.
ballast wagons. (800 words & fig.)

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623 & 656
Gazette, No. 4, January 26, p. 126, No. 5, uary 2, p. 158, and No. 6, February 9.
ort services and the war — 22, 23 and 24. vords.)

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624 .1 (.42), 625 .13 (.42) & 66 (.42)
Gazette, No. 5, February 2, p. 147.
ING (H. J. B.) and GLOSSOP (R.). — **Che-nsolidation of ground** in railway work. (2 400 fig.)

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621 .95 (.42)
Gazette, No. 5, February 2, p. 152.
locomotive boiler-shell drilling machine. (750 fig.)

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623 (.42) & 656 .2 (.42)
Gazette, No. 5, February 2, p. 154.
railways and the war — 5. (Figures.)

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656 .257 (.42)
Gazette, No. 6, February 9, p. 177.
for electric lever interlocking (standard table nded by Committee of Institution of Railway Engineers). (1 400 words & fig.)

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629 .113.4 (.42) & 662 (.42)
Gazette, No. 6, February 9, p. 182.
(Brian). — **Producer gas for commercial ve-**ontinued from January, 12, issue). (4 500 words

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621 .431.72 (.73) & 656 .261 (.73)
Gazette, No. 6, February 9, p. 187.
ail vehicles in the U. S. A. (Railcar design Canada given a wider application — **loco-nits** developed **for branch-line and yard ser-**0 words & fig.)

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385 .15 (.42) & 623 (.42)
Gazette, No. 6, February 9, p 198.
nment control of railways. Outline of financial nents between the Minister of Transport, the lgamated Companies and the L. P. T. B. (1 500

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621 .338 (.42)
Railway Traction, p. 10, supplt. to the Railway tte, February 2.
rains for the Liverpool-Southport line. (5 100 fig.)

1940 385 .114 (.73) & 621 .431 .72 (.73)
Diesel Railway Traction, p. 2, supplt. to the Railway Gazette, January 19.
Long-distance Diesel working in the U. S. A. (2 700 words & fig.)

1940 621 .431.72 (.47 + .48)
Diesel Railway Traction, p. 5, supplt. to the Railway Gazette, January 19.
Railcars in the Baltic States. (2 200 words & fig.)

1940 621 .431.72 (.72)
Diesel Railway Traction, p. 8, supplt. to the Railway Gazette, January 19.
PERKINSON (T. F.). — New railways in Mexico inaugurate **Diesel operation.** (1 750 words & fig.)

1940 621 .431.72 & 656 .221
Diesel Railway Traction, p. 10, supplt. to the Railway Gazette, January 19.
KOFFMANN (J. L.). — **Railcar resistance and performance curves.** (2 000 words & fig.)

Railway Magazine. (London.)

1940 656 .222.1 (093 (.42)
Railway Magazine, No. 512, February, p. 65.
TURNER (J. T. H.) and GREHAN (M.). — The G. W. R. **record run of 1848.** (3 000 words & fig.)

1940 656 .222.1 (.73)
Railway Magazine, No. 512, February, p. 69.
American **express trains** in the summer of 1939. (4 000 words.)

1940 656 .252 (.42)
Railway Magazine, No. 512, February, p. 93.
Engine headcodes. Familiar features of operation — XV. (3 200 words & fig.)

Railway Mechanical Engineer. (New York.)

1940 621 .132.8 (.73)
Railway Mechanical Engineer, January, p. 1.
12 coal-burning **2-8-8-4 locomotives for heavy passenger and freight service,** Southern Pacific. (5 600 words & fig.)

1940 625 .232 (.73)
Railway Mechanical Engineer, January, p. 8.
High-tensile steels used in construction of Delaware & Hudson 76-passenger **light-weight coaches.** (4 500 words & fig.)

1940 656 .281 (.73)
Railway Mechanical Engineer, January, p. 13.
Bureau of Safety reports on « City of San Francisco » **derailment.** (3 500 words.)

1940 62 (01 & 669 .1
Railway Mechanical Engineer, January, p. 15.
PRIEST (H. M.). — **Designing for high tensile steels.** — IV. **Charts and formulas** for the solution of problems involving a combination of stresses and working formulas based on the specifications for **post office cars.** (Parts I and II appeared in the May and June, 1936, issues; Part III in the December, 1939, number.) (3 500 words & fig.)

Railway Signaling. (Chicago.)

1940 **313 : 656 .25 (.71 + .73)**

Railway Signaling, January, p. 21.

Signaling construction increases in 1939. (2 300 words. tables & fig.)

1940 **656 .25 (0 (.73)**

Railway Signaling, January, p. 27.

Signaling inspections and reports on the Wabash. (7 200 words & fig.)

1940 **656 .25 (0 (.73)**

Railway Signaling, January, p. 35.

Pennsylvania **signaling testing procedure.** (5 000 words.)

In Spanish.

Ferrocarriles y Tranvías. (Madrid.)

1940 **625 .13 (.460)**

Ferrocarriles y Tranvías, n° 65, enero, p. 5.

SUAREZ BLANCO (R.). — **Reconstrucción del viaducto** de Ormáiztegui. (7 000 palabras & fig.)

1940 **625 .2**

Ferrocarriles y Tranvías, n° 65, enero, p. 17.

de GOICOECHEA (A.). — El **aligeramiento** en los ferrocarriles de via de un metro. (2 500 palabras & fig.)

Revista del Colegio de Ingenieros de Venezuela. (Caracas-Venezuela.)

1939 **624 .2**

Revista del Colegio de Ingenieros de Venezuela, n° 132, julio, agosto, septiembre, p. 452.

HERRERA (R. F.). — Abacos para el **cálculo de vigas doble T de acero,** de perfil normal, apoyadas en ambos extremos. (500 palabras & fig.)

In Italian.

Annali dei lavori pubblici. (Roma.)

1939 **656 .211 (.45)**

Annali dei lavori pubblici, n° 10, ottobre, p. 1059.

Opere di viabilità ordinaria alla **stazione di Treviso.** (850 parole & fig.)

1939 **624 .2**

Annali dei lavori pubblici, n° 11, novembre, p. 1141.

GRIOLI (Dr. G.). — **Sollecitazioni di una struttura elicoidale** incastrata agli estremi. (2 000 parole & fig.)

1939 **624 .1 (.45)**

Annali dei lavori pubblici, n° 12, dicembre, p. 1252.

Cassoni per fondazioni pneumatiche del nuovo ponte San Paulo in Roma. (1 000 parole & fig.)

L'Ingegnere. (Roma.)

1940 **62. (01**

L'Ingegnere, gennaio, p. 35.

COLONNETTI (G.). — **Cemento armato con** Isteg. (500 parole & fig.)

Rivista tecnica delle ferrovie italiane. (Rc

1940 **625 .13**

Rivista tecnica delle ferrovie italiane, 15 gennaio

DRAGONE (S.). — La demolizione e la ricostr **del cavalcavia** di S. Salvario in stazione di Torino Nuova. (2 800 parole & fig.)

1940

Rivista tecnica delle ferrovie italiane, 15 gennaio.

PERFETTI (A.). — L'economia del ferro nelle **ture in cemento armato.** (1 700 parole.)

1940 **62**

Rivista tecnica delle ferrovie italiane, 15 gennaio,

TONNI (G.). — Controllo della tesatura della **di contatto** delle linee ferroviarie esercitate a cc continua. (4 500 parole & fig.)

In Dutch.

De Ingenieur. (Den Haag.)

1940 **62**

De Ingenieur, Nr. 2, Februari, p. Bt. 5.

EMMEN (J.). — Het **berekenen van boogbr** met verstijvingsligger en de Rijksbruggenbouw. woorden & fig.)

1940 **62**

De Ingenieur, Nr. 7, 16 Februari, p. E. 23.

DELLAERT (C.). — De **metadyne** (metadyn (2 500 woorden & fig.)

Spoor- en Tramwegen. (Utrecht.)

1940 **385 .572 (**

Spoor- en Tramwegen, Nr. 3, 3 Februari, p. 43.

HALBERSTADT (H. A. C.). — Twee ma « **School voor klerken** bij den dienst van het v der N. S. ». (3 500 woorden.)

1940 **62**

Spoor- en Tramwegen, Nr. 4, 17 Februari, p. 66.

VANDERPUTTE (E.). — Het **remmen der rei treinen.** (2 400 woorden & fig.)

1940 **625 .111 (.43) & 625 .162**

Spoor- en Tramwegen, Nr. 4, 17 Februari, p. 74.

OVERMANN (J.). — Nieuwe Duitsche wet **kruisingen** tusschen spoorlijnen en verkeersv (2 400 woorden.)

M. Weissenbruch Co., Ltd., Printer of the King, 49, rue du Poinçon, Bruxelles.

MONTHLY BIBLIOGRAPHY OF RAILWAYS [1].

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(MAY 1940)

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I. — BOOKS.

In French.

721. (02

Y (H.), ingénieur E. C. P.
ulaire du bâtiment et des travaux publics.
et Liége, Librairie polytechnique Ch. Béranger.
net de poche (9 × 14 cm.) de 241 pages avec
(Prix : 25 fr. français.)

621. (02

INE (Robert).
ulaire de construction mécanique.
, Librairie polytechnique Ch. Béranger, 15, rue
nt-Pères. Un vol. (9 × 14 cm.) de 290 pages.
25 fr. français.)

62. (02

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et Liége, Librairie Polytechnique Béranger.
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s.)

656 (.493)

ENS (H.).
Administrations des transports et les transpor-
ar rail et par route.
elles, Imprimerie de l'Office des Chèques pos-
7, rue de Louvain. 1 volume (14.5 × 20.5 cm.)
pages.

In German.

621. (02

ER (Dr.-Ing. W.).
lers Hilfstabellen für technische Berechnungen
onstruktionen. Eine Auswahl Regeln und Normen
nutzung im gewerblichen Unterricht sowie zum
en Gebrauch im Konstruktionsbüro. (Haeders
icher für Maschinenbau). Unter Mitwirkung be-
r Fachleute.
n W. 62, 1939, Verlag Carl Schmidt & Co., XIII,
iten. (Preis : Kartoniert 2 R. M.)

1940 625 .143. (06

IV. Internationale Schienentagung in Düsseldorf 1938.
Düsseldorf, Verlag Stahleisen; 1 Band, DIN A 4, 255 Seiten mit 484 Abb. (Preis : Kartoniert 20 R. M.)

In English.

1939 62 (01, 669 & 691

BURNS (R. M.) and SCHUH (A. E.).

Protective coatings for metals (American Chemical Society Monograph Series, No. 79). — A vol., 8vo, of 407 pages.

New York, Reinhold Publishing Corporation; London, Chapman and Hall Ltd. (Price : 32 sh. 6 d.)

1940 62 (01 & 669 .1

HUDSON (Dr. J. C.).

The **Corrosion of Iron and Steel.** A general account of the work of the Corrosion Committee of the Iron and Steel Institute and the British Iron and Steel Federation.

London, Chapman & Hall, Ltd. (Price : 18 sh. net.)

1940 625 .254

MATHERS (C. H.).

The Vacuum Brake, its Theory, History and Practice as used on the Great Western Railway. A vol. (6 1/2 × 4 1/2 inches) of 78 pages, illustrated. Limp, cloth cover.

Shrewsbury, Wilding & Son Ltd., 33, Castle street. (Price : 1 sh. 6 d. net.)

1940 621 .116 (06 (.73)

Proceedings of 1939 Annual Meeting of the **Master Boiler Makers' Association.**

Albert F. Stiglmeier, Secretary, 29, Parkwood Street, Albany, N. Y. — 263 pages. (Price : $ 3.)

6. 385. (05]

II. — PERIODICALS.

In French.

nnales des Ponts et Chaussées (Paris).

656 (.64)

s des Ponts et Chaussées, septembre, p. 217.
MANDIN (A.). — La **coordination** du rail et de
e au Maroc. (6 000 mots.)

Bulletin des transports internationaux par chemins de fer. (Berne.)

1940 385 .63

Bull. des transp. intern. par ch. de fer, février, p. 53.

WEBER (K. E.). — Les défectuosités du chargement effectué par l'expéditeur, en tant que circonstances excluant la **responsabilité du ch. de fer.** (4 000 mots.)

[1] The numbers placed over the title of each book are those of of the decimal classification proposed by the Railway Congress ntly with the Office Bibliographique International, of Brussels. (See « Bibliographical Decimal Classification as applied to ay Science », by L. WEISSENBRUCH, in the number for November 1897, of the *Bulletin of the International Railway Congress*, 9).

1940 **313 .385 (.497.1)**
Bull. des transp. intern. par ch. de fer, février, p. 82.
Les **chemins de fer du Royaume yougoslave** pendant l'exercice 1938. (1 200 mots.)

Bulletin technique de la Suisse romande. (Lausanne.)

1940 **385**
Bull. techn. de la Suisse romande, n° 5, 9 mars, p. 49.
Questions d'actualité ferroviaire : La **vitesse des trains,** par A. MARGUERAT. (3 000 mots & fig.) — La **voie,** par M. JATON. (3 000 mots & fig.) (A suivre.)

Génie civil. (Paris.)

1940 **621 .392 (.493) & 624 .62 (.493)**
Génie Civil, n° 3002, 24 février, p. 140.
Les **ponts métalliques** du Canal Albert, de Liége à Anvers. (1 300 mots & fig.)

1940 **621 .331 (.44)**
Génie Civil, n° 3005, 16 mars, p. 188.
Sous-station mobile de traction pour la partie électrifiée des Chemins de fer français. (800 mots & fig.)

La Technique moderne. (Paris.)

1940 **656 .254**
La Technique Moderne, 1er et 15 février, p. 42.
Les **appareils radio-électriques de liaison et de sécurité.** (2 700 mots & fig.)

1940 **621 .132.5 (.44)**
La Technique Moderne, 1er et 15 février, p. 47.
Locomotive « Santa-Fé » de la Région Est de la S. N. C. F. (400 mots & fig.)

1940 **621 .89**
La Technique Moderne, 1er et 15 mars, p. 65.
BRILLIÉ (H.). — L'onctuosité des **lubrifiants** et le fonctionnement des machines. (5 000 mots & fig.) (A suivre.)

1940 **656 .136 (.44)**
La Technique Moderne, 1er et 15 mars, p. 71.
PINGET (R.). — Le **trolleybus** en France. Développement récent et technique actuelle. (4 000 mots & fig.)

L'Ossature métallique. (Bruxelles.)

1940 **624 .51 (.71)**
L'Ossature métallique, mars, p. 101.
Le **pont suspendu** de Lions' Gate à Vancouver (Colombie britannique). (1 300 mots & fig.)

1940 **621 .338 (.493) & 625 .215 (.493)**
L'Ossature métallique, mars, p. 114.
FORTUN (J.). — **Bogies à suspension indépendante** des voitures électriques de la ligne Bruxelles-Anvers. (1 100 mots & fig.)

1940 **624**
L'Ossature métallique, mars, p. 125.
CAMPUS (F.). — Nouveaux essais sur modèles de **nœuds rigides.** (4 500 mots & fig.)

Revue Générale des Transports. (Paris.

1940 **621 .33**
Revue générale des transports, n° 76, 15 janvier
RAWORTH (A.). — Méthodes modernes d'él**cation** des voies ferrées. Les développement Southern Railway. (1 050 mots & tableau.)

1940 **385**
Revue générale des transports, n° 77, 15 février,
MERCEY (J.). — La **voie ferrée** Indochine-Tha (1 200 mots & fig.)

1940 **625 .232**
Revue générale des transports, n° 77, 15 février,
Le problème du **transport des blessés** militai civils. L'effort des Compagnies anglaises de chem fer. (1 350 mots.)

1940 **385 .4 (**
Revue générale des transports, n° 78, 15 mars, p.
HARCAVI (G.). — Le problème de la **coordi des compétences des services actifs** du mouveme la traction et de la voie. Leur collaboration ratio sur le Réseau de la Société Nationale des Chemi fer belges. (2 100 mots & fig.)

Revue universelle des Mines. (Liége.)

1940 **621**
Revue universelle des mines, n° 3, mars, p. 83.
COUVREUR (S.). — Aperçu sur les **procédés d ration** et de déminéralisation des eaux. (2 700 mo

Traction nouvelle. (Paris.)

1939 **385. (091**
Traction nouvelle, septembre-octobre--novembre-dé bre, p. 162.
LAVIGNON (L.). — Traction nouvelle sur les **mins de fer Algériens.** (2 000 mots, 1 carte & fig.)

1939 **385**
Traction nouvelle, septembre-octobre-novembre-dé bre, p. 168.
DUGAS (R.). — **Programme quinquennal** de la C. F. (2 200 mots).

1939 **621 .431.72**
Traction nouvelle, septembre-octobre-novembre-dé bre, p. 178.
Le développement des **services d'autorails** en A que du Sud. (3 500 mots, 1 carte & fig.)

1939 **621**
Traction nouvelle, septembre-octobre-novembre-dé bre, p. 184.
GARNIER. — Les **sous-stations sur wagons** divers pays. (2 000 mots & fig.)

In German.

Der Bahn-Ingenieur. (Berlin).

1940 **621 .335 (.43) & 621 .337**
Der Bahn-Ingenieur, Nr. 7, 18. Februar, S. 77.
KASTNER (N.). — Studie über eine **automa Fahrtwendereinstellung** bei Lok E 88. (2 000 W & Abb.)

656 .21 (.43)

n-Ingenieur, Nr. 8, 25. Februar, S. 85.
STELLER. — **Betriebsorganisation** unter besonderücksichtigung der Betriebsaufgaben der Betsvorstände. (8 500 Wörter.)

625 .175 (.43)

n-Ingenieur, Nr. 9, 3. März, S. 97.
SBAUER (K.) und MARTIN. — **Kleinkraft-** (4 000 Wörter & Abb.)

621 .138

hn-Ingenieur, Nr. 9, 3. März, S. 103.
TENSTEIN (F.). — Ein neues Verfahren zur **ng von Rohren.** (1 500 Wörter & Abb.)

621 .131.2

hn-Ingenieur, Nr. 9, 3. März, S. 105.
Z (A.). — **Prüfmesseinrichtungen** für den **Lokoahmen** und den **Achsabstand der Lokomotivse.** (950 Wörter & Abb.)

621 .138 & 725 .33

hn-Ingenieur, Nr. 10, 10. März, S. 109.
DERSTRASSER. — **Maschinelle Anlagen** des **ahnbetriebs** einschliesslich der Wasserversorgung. Wörter.)

Elektrische Bahnen. (Berlin.)

621 .33 (.3)

ische Bahnen, Heft 1, Januar, S. 1.
SCHLÄGER (H.). — Der **Stand** der **elektrischen derung** in den **ausserdeutschen** Ländern. (4 000 , Abb. & Tafeln.)

621 .335 (.485) & 656 .222.1 (.485)

ische Bahnen, Heft 1, Januar, S. 8.
ER (H. Dir.) und OTTOSSEN (J. Obering.). — ahmen für **erhöhte Zuggeschwindigkeit** und die **elektrische Schnellzuglokomotive** bei der Schwe- Staatsbahn. (4 000 Wörter, Diagr. & Abb.) folgt.)

Glasers Annalen. (Berlin.)

621 .13 (.73) & 625 .2 (.73)

Annalen, Heft 3, 1. Februar, S. 21.
RNEKKE (F.). — **Fortschritte im Lokomotiv-Vagenbau** bei den Eisenbahnen der Vereinigten im Jahre 1937-38. (2 500 Wörter & Zahlentaf.)

625 .245

Annalen, Heft 3, 1. Februar, S. 23.
USEN (O. Dipl.-Ing.). — Die **Aufhängung** von **übeln** am **Krantragbügel** im Hinblick auf richtladung. (2 000 Wörter & Abb.)

656 .212.8

Annalen, Heft 4, 15. Februar, S. 27.
MELZER (K.). — Zur **Entwicklung** der **Brücken-** (4 200 Wörter & Abb.)

Die Lokomotive. (Bielefeld-Berlin.)

1940 **621 .132.8**

Die Lokomotive, Nr. 3, März, S. 34.
Dampflokomotiven mit **Einzelachsantrieb** (450 Wörter & Abb.)

1940 **621 .131 (.43) & 621 .132.8 (.43)**

Die Lokomotive, Nr. 3, März, S. 35.
BEIL (W. Obering..). — Die Entwicklung der **Stromlinien-Lokomotiven** der Deutschen Reichsbahn. (3 350 Wörter & Abb.)

1940 **656 .222.1 (.43)**

Die Lokomotive, Nr. 3, März, S. 40.
Die **schnellsten Züge** der Reichsbahn. (750 Wörter & Zahlentafeln.)

Organ für die Fortschritte des Eisenbahnwesens. (Berlin.)

1940 **621 .135.4 (.43)**

Organ für die Fortschritte des Eisenbahnwesens, Heft 4, 15 Februar, S. 67.
SCHRAMM (G.). — **Zulässige Fahrgeschwindigkeiten** in **Gleisbogen** mit Rücksicht auf die Überhöhungs- und Krümmungsverhältnisse. (7 500 Wörter & Abb.)

1940 **625 .141 (.43) & 625 .142 (.43)**

Organ für die Fortschritte des Eisenbahnwesens, Heft 5, 1. März, S. 79, u. Heft 6, 15. März, S. 93.
VOGEL (Dr.-Ing. R.). — **Veränderung** der **Bettung** unter Stahl- und Holzschwellen. (11 000 Wörter, Abb. & Zahlentafeln.)

1940 **621 .39 (.47) & 625 .143 (.47)**

Organ für die Fortschritte des Eisenbahnwesens, Heft 5, 1. März, S. 91.
SALLER (Dr.). — **Härtung** von **Schienenenden** in UdSSR. (500 Wörter.)

Verkehrs technische Woche. (Berlin.)

1940 **656 .212.5 (.43)**

Verkerhrstechnische Woche, Heft 9/10, 28. Februar/6. März, S. 63.
KLINKMÜLLER (Dr.-Ing. J.). — **Rangierzettelbeförderungsanlage.** (3 300 Wörter & Abb.)

Zeitschrift des Vereines deutscher Ingenieure (Berlin.)

1940 **621 .392 & 665 .882**

Zeitschrift des Vereins deutscher Ingenieure, Nr. 8, 24. Februar, S. 132, & Nr. 10, 9. März, S. 173.
CORNELIUS (H.). — **Schweissen** von korrosions- und hitzebeständigen Stählen. Austenitische Stähle. (4 500 Wörter & Zahlentafeln.)

1940 **621 .436**

Zeitschrift des Vereins deutscher Ingenieure, Nr. 8, 24. Februar, S. 136.
Spülvorgang bei **Zweitaktmotoren.** (1 500 Wörter & Abb.)

1940 **621 .432**

Zeitschrift des Vereins deutscher Ingenieure, Nr. 8, 24. Februar, S. 137.
Untersuchungen an **Kolbenringen** raschlaufender **Verbrennungsmotoren.** (700 Wörter.)

Zeitschrift für das gesamte Eisenbahn-Sicherungs- und Fernmeldewesen. (Berlin.)

1940 **656 .256 (.436)**

Zeitschrift für das gesamte Eisenbahn-Sicherungs- und Fernmeldewesen, Nr. 4, 10. März, S. 29.

BIESOK (W. Dipl.-Ing.). — Die **Sicherungs-** und **Streckenblockanlagen** österreichischer Bauart (Fortsetzung.) (2 500 Wörter & Abb.) (Forts. folgt.)

Zeitung des Vereins mitteleuropäischer Eisenbahnverwaltungen. (Berlin.)

1940 **385 (.4)**

Zeitung des Vereins mitteleuropäischer Eisenbahnverwaltungen, Nr. 8, 22. Februar, S. 91, Nr. 9, 29 Februar, S. 103, Nr. 10, 7 März, S. 119, Nr. 11, 14. März, S. 129.

Rückblick auf das **Jahr 1939.** (31 750 Wörter). (Fortsetzung folgt.)

In English.

Bulletin, American Railway Engineering Association. (Chicago.)

1940 **625 .142.2 (.73) & 691 (.73)**

Bulletin, Amer. Railway Engineering Assoc., No. 416, February, p. 477.

Report of Committee XVII. — **Wood preservation.** — Progress reports on service test records for treated ties. — Piling for marine construction. — Destruction by termites and prevention. — Present practice as to preservatives used. (7 000 words, tables & fig.)

1940 **625 .12 (.73) & 625 .141 (.73)**

Bulletin, Amer. Railway Engineering Assoc., No. 416, February, p. 519.

Report of Committee I. — **Roadway and ballast.** — Vitrified pipe culverts. — Settlement shrinkage, subsidence of roadway. — Slope protection. — Tunnel lighting. — Fences. — Ballast section design. — Use of asphalt in ballast. Etc. (16 000 words, tables & fig.)

1940 **625 .14 (.73)**

Bulletin, Amer. Railway Engineering Assoc., No. 416, February, p. 553.

Report of Committee V. — **Track.** — Proposed revision of Manual (string lining of curves, specifications for track tools, tie plates for R E rail sections, spirals for high speeds. — Plans for switches, crossings, frogs, and Track construction in paved streets (Plans form Part Two of Bulletin No. 416). — Corrosion of rails and fastenings in tunnels. — Tie plates for R E rail sections. — Bolt tension for proper supporting of joints. — Prevention of damage due to brine drippings on track structures. Etc. (15 000 words, tables & fig.)

1940 **625 .143**

Bulletin, Amer. Railway Engineering Assoc., No. 416, February, p. 609.

Report of Committee IV. — **Rail.** — Reports on mill practice and manufacture as they affect rail quality and failures. — Compilation of statistics of all rail failures and transverse fissure failures. — Joint bar failures. Etc. (9 000 words, tables & fig.)

1940

Bulletin, Amer. Railway Engineering Assoc., N
February, p. 639.

Report of Special Committee on Complete R
and Track Structure. — **Traffic classification o
tracks. Complete roadway and track for variou
and traffic densities.** (1 500 words & tables.)

1940 **62**

Bulletin, Amer. Railway Engineering Assoc., N
February, p. 647.

Report of Committee III. — **Ties.** — Compilat
ties subjected to trial in substitution of wood. —
wal averages and costs per mile. — Dimensions
Splitting of ties. Etc. (3 500 words & tables.)

Engineer. (London.)

1940 **62 (01 &**

Engineer, February 16, p. 156.

The **resistance of copper to soil corrosion.** words, tables & fig.)

1940 **62**

Engineer, February 23, p. 189.

Spot welding of light alloys. (3 700 words &

1940 **621 .392 (.73) & 625 .13**

Engineer, February 23, p. 191.

Arc-welded river tunnel for Chicago. (400 wo
fig.)

1940 **621 .132.8 (.44) & 621 .133.3**

Engineer, March 1, p. 199.

French **locomotive with Velox boiler** (2 900 wo
fig.)

1940 **62 (01 (.73) & 625 .212**

Engineer, March 1, p. 206.

Tests of steel railway wheels. (400 words & fig.

1940 **621 .132.3**

Engineer, March 8, p. 222; March 15, p. 246.

POULTNEY (E. C.). — Heavy **passenger en**
South African Railways. (11 500 words & fig.)

1940 **621**

Engineer, March 8, p. 224.

ANDREWS (W.). — Some observations on **me
arc fluxes.** (4 500 words & fig.)

1940 **62**

Engineer, March 8, pp. 249 and 261.

YORATH LEWIS (W.) and ROBERTSON (Str
— The **Lewis boiler.** — Abstract and discu
(I. M. E.) of a paper entitled : « The circulati
water and steam in water-tube boilers and the ra
simplification of boiler design. » (9 500 words & f

1940 **62 (01 & 62**

Engineer, March 15, p. 251.

BALL (J. D. W.). — Net sectional area of te
members. (1 000 words, tables & fig.)

Engineering. (London.)

625 .23 (.42)

ering, No. 3866, February 16, p. 165.
NIER (W. A.). — **Lightweight passenger rolling** (11 000 words, 2 tables & fig.)

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385 .15 (.42) & 623 (.42)

ering, No. 3867, February 23, p. 201.
railway settlement (Government control). (1 000)

016

ering, No. 3868, March 1, p. 217.
DFORD (S. C.). — Efficiency in **documentation.** words.)

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621 .338 (.42)

ering, No. 3868, March 1, p. 222.
rolling stock for the Liverpool and Southport . M. S. R. (2 500 words & fig.)

Engineering News-Record. (New York.)

624 .1 & 721

eering News-Record, February 1, p. 62.
VMARK (Prof. N. M.). — **New data on struc- and foundations** (Reducing settlement. — Wind g. — Continuous concrete slabs). (3 200 words &

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624 & 721

eering News-Record, February 15, p. 73.
VMAN (Waldo C.). — **Bridges and buildings** . (2 000 words & fig.)

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656 (.73)

eering News-Record, February 15, p. 76.
L (Charles S.). — 1939, record year for transport. words & fig.)

Journal and Proceedings, Institution of Mechanical Engineers. (London.)

621 .18 & 621 .31

edings, Institution of Mechanical Engineers, Fe- ruary, p. 305.
ARCE (Sir Leonard). — A review of forty years' opment in **Mechanical Engineering Plant** for **r Stations.** (20 000 words, 9 tables & fig.)

Mechanical Engineering. (New York.)

62 (01 & 694

anical Engineering, March, p. 189.
RNHARD (R. K.), PERRY (Thomas D.), and N (E. G.). — **Superpressed plywood** bonded with osetting synthetic-resin adhesives. (3 500 words, & fig.)

Modern Transport. (London.)

385 .15 (.42) & 623 (.42)

n Transport, February 17, p. 5.
ernment control of the railways. Full text of **ment on compensation terms.** (1 200 words.)

623 (.42) & 656 (.42)

Modern Transport, February 17, p. 13.
Transport in war time. Lord Stamp on **railway difficulties.** Etc. (1 300 words & fig.)

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656 .1 & 656 .261

Modern Transport, February 24, p. 5.
Equipment for road-rail combined transport. No. 9. The Crescent Fives-Lille System (France). (800 words & fig.)

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621 .335 (.494)

Modern Transport, February 24, p. 7.
The Loetschberg Ry. **Development of locomotive power** for over a quarter century. Sécheron 6 000-H.P. design. (2 200 words & fig.)

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621 132.7 (.73) & 621 .431.72 (.73)

Modern Transport, March 2, p. 3.
Shunting locomotives in the U. S. A. Examples of recent design (Baldwin). (1 300 words & fig.)

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621 .335 & 621 .338

Modern Transport, March 16, p. 3.
ANDREWS (H. H.). — Equipment of **electric motor coach trains.** Review of recent developments. (To be continued.) (1 800 words & fig.)

Oil Engine. (London.)

621 .431.72 (.73) & 656 .222.1 (.73)

Oil Engine, March, p. 346.
MANN (Chas. F. A.). — **Streamline train competition** in Florida (Seabord Air Line, and Atlantic Coast Lines and Florida East Coast Railway). (500 words & fig.)

Railway Age. (New York.)

621 .132.8 (.73)

Railway Age, February 3, p. 239.
Southern Pacific **oil-burning 4-8-8-2 cab-ahead locomotives.** (1 600 words & fig.)

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625 .142.2 (.73) & 691 (.73)

Railway Age, February 3, p. 241.
Better **timber for railroad uses** (36th Annual Convention of American Wood Preservers Association). (4 500 words & fig.)

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621 .13 & 621 .431.72

Railway Age, February 3, p. 249.
How to increase **terminal locomotive efficiency. Steam and diesel-electric power compared** in yard operating studies. (5 500 words & fig.)

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62 (01,, 625 .143.2 & 625 .143.3

Railway Age, February 10, p. 277.
DRAKE (Harcourt C.). — Is the **transverse fissure problem** growing? (Adapted from paper before the

University of Michigan. Conference on New Technologies in Transportation. (3 600 words & fig.)

1940 **625 .232 (.73)**
Railway Age, February 10, p. 284.
Southern Pacific installs new **14-car daylight trains.** (3 000 words & fig.)

1940 **385 .114 (.71) & 621 .13 (0**
Railway Age, February 17, p. 317.
MACKEN (James R.). — **Modern locomotives. — Their influence on railway operation.** A study of the costs of locomotive operation on the Canadian Pacific and how such costs were affected by changing conditions. (2 500 words & fig.)

1940 **625 .142.2 (.73) & 691 (.73)**
Railway Age, February 17, p. 320.
HARRIS (C. W.). — Santa Fe secures large **return from treated crossties.** A study of tests involving 455 miles of tracks and a quarter million ties. (4 500 words, tables & fig.)

1940 **656 .256.3 (.73) & 656 .258 (.73)**
Railway Age, February 17, p. 325.
St. Louis **signals municipal bridge.** Automatic block and 2 interlockings provide for maximum track capacity and routing of trains. (1 200 words & fig.)

1940 **625 .23 (.73), 656 .222.1 (.73) & 656 .23 (.73)**
Railway Age, February 17, p. 330.
KELLY (George A.). — Remaking transport package. Railroads awaken to tempo of American living and do remarkable job of **merchandizing lightweight trains.** (2 200 words & fig.)

1940 **621 .431.72 (.73) & 625 .232 (.73)**
Railway Age, February 24, p. 353.
Missouri Pacific gets **aluminium streamliners** from American Car and Foundry Co. (New Eagle trains embodying de luxe features). (5 000 words & fig.)

1940 **624 .2 & 656 .222.1**
Railway Age, February 24, p. 364.
VAN NESS (R. A.). — **Do higher speeds increase stresses in bridges?** Santa Fe undertakes experiments to determine effect. — Discloses beneficial effect of **ballasted decks** in lessening impact (3 200 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1940 **624 (.73) & 625 .13 (73)**
Railway Engineering and Maintenance, January, p. 80.
HAGGANDER (G. A.). — **Strengthening old bridges** to meet present-day demands (Paper presented at the Convention of Amer. Ry. Bridge & Building Ass., Oct. 1939). (6 500 words & fig.)

1940 **625 .142.2 (.73) & 691 (.73)**
Railway Engineering and Maintenance, January, p. 84.
HARRIS (G. W.). — What can we expect from **treated ties?** (Paper before Convention of Amer. Wood Preservers' Ass., Jan. 24, 1939). (6 400 words, tables fig.)

1940 **625 .144.4 (.73**
Railway Engineering and Maintenance, January, p. 8
Delaware & Hudson employs ingenious method **loading 1 40-ft. rails.** (3 600 words & fig.)

1940 **625 .143**
Railway Engineering and Maintenance, January, p. 9
BRONSON (C. B.). — What determines the life **rail?** (2 400 words & fig.)

Railway Gazette. (London.)

1940 **656 .222.1 (.4 + .73**
Railway Gazette, February 16, p. 215.
ALLEN (Cecil J.). — World **railway speed in 193**
Summary of fastest runs; increase in aggregate hig speed mileage during 9 last years (Europe and U.S.A Proportions by steam, diesel and electric haulag (2 300 words, tables & fig.)

1940 **621 .133**
Railway Gazette, February 16, p. 220.
TRASK (E. D.). — The **smokebox of streamlin engines.** (See also L. N. E. R. Magazine, Oct. 193 (1 000 words & fig.)

1940 **625 .144.4 (.44) & 625 .173 (.44**
Railway Gazette, February 16, p. 222.
Novel (bucket-dredger type) **ballast screening m chine.** (750 words & fig.)

1940 **623 & 6**
Railway Gazette, Febr. 16, p. 230, No. 25; Febr. 2 p. 266, No. 26; March 1, p. 288, No. 27; March p. 354, No. 28.
Transport services and the war. (12 600 words & fig

1940 **656 .255 (.945) & 656 .256.2 (.94**
Railway Gazette, February 23, p. 251.
Single-line signalling in Victoria (lever lock and tra control system). (500 words.)

1940 **625 .14 (0**
Railway Gazette, February 23, p. 254.
Track stress research (more outstanding parts report of Messrs. W. E. Gelson and E. A. Blackwood India). (2 000 words.)

1940 **621 .132.3 (.81**
Railway Gazette, February 23, p. 256.
Redesigned **4-6-2 locomotives,** Leopoldina Railwa **(back end altered to burn Brazilian coal).** (1 300 wor & fig.)

1940 **625 .174 (.55**
Railway Gazette, February 23, p. 259.
Snow ploughs for the Iranian State Railways. (5 words & fig.)

1940 **621 (.42) & 656 .259 (.42)**
ilway Gazette, March 1, p. 288.
)ALZIEL (J.). — The **Outdoor Machinery Depart-nt** of a British main-line railway. I. (3 000 words fig.)

1940 **385 (091 (.497.2)**
ilway Gazette, March 1, p. 291.
The **Trans-Balkan Railway.** (2 000 words, map & fig.)

1940 **656 .283**
ilway Gazette, March 1, p. 314.
Six signals passed unseen. Ministry of Transport port on collision, Bletchley, Oct. 1939. (5 600 words fig.)

1940 **624 (.493)**
ilway Gazette, March 8, p. 335.
Welded bridge failures in Belgium (Albert Canal). 00 words & fig.)

1940 **629 .113.4**
ilway Gazette, March 8, p. 339.
BRIAN REED. — **Producer gas** for commercial vehi-s (continued). (3 500 words & fig.)

1940 **623 (.42) & 656 .1 (.42)**
ilway Gazette, March 8, p. 344.
Road transport and the war. — 6. — (3 000 words & .)

1940 **621 .431.72 (∞)**
esel Railway Traction, p. 14. Supplt. to the Railway Gazette, February 16.
Diesel traction progress in 1939. (9 000 words & fig.)

1940 **621 .335 (.42)**
ectric Railway Traction, p. 22. Supplt. to the Railway Gazette, March 1.
Works locomotives for electrified lines (L. P. T. B.). 200 words & fig.)

1940 **621 .33 (.492)**
ectric Railway Traction, p. 24. Supplt. to the Railway Gazette, March 1.
Dutch electrification plans (70 miles of route con-rted to 1 500-volt D.C. — Rolling stock being built rebuilt. (1 500 words & fig.)

1940 **621 .33 (.494)**
ectric Railway Traction, p. 25. Supplt. to the Railway Gazette, March 1.
Electrification of the Swiss South-Eastern Railway. 700 words & fig.)

1940 **621 .33 (.493) & 656 .222 (.493)**
ectric Railway Traction, p. 28. Supplt. to the Railway Gazette, March 1.
Intensive working on the Brussels-Antwerp electric ie (1 500 words & fig.)

The Railway Magazine. (London.)

1940 **656 .222.1 (.42)**
Railway Magazine, March, p. 158.
« MERCURY ». — British **express trains** in 1939. (2 500 words & 3 tables.)

Railway Mechanical Engineer. (New York.)

1940 **621 .133**
Railway Mechanical Engineer, February, p. 43.
BRANDT (C. A.). — The **locomotive boiler** (design and proportions...) (To be concluded.) (4 200 words, tables & fig.)

1940 **621 .118 (.73)**
Railway Mechanical Engineer, February, p. 52.
Locomotive Inspection. Report (Bureau of Locom. Inspection, I. C. C.). (1 300 words, tables & fig.)

1940 **621 .335 (.73) & 621 .431.72 (.73)**
Railway Mechanical Engineer, February, p. 56.
Baldwin **diesel-electric switchers** (8 and 6-cyl., 1 000 and 600-H.P. engines), Atchison, Topeka & Santa Fe. (3 000 words & fig.)

1940 **62 (01 (.73) & 625 .246 (.73)**
Railway Mechanical Engineer, February, p. 60.
Comparative service tests of USS **Cor-Ten vs. copper steel** (coke carrying hopper cars). (1 000 words & fig.)

1940 **625 .243 (.73)**
Railway Mechanical Engineer, February, p. 62.
Automobile box cars (50-tons capacity, lightweight). (1 300 words & fig.)

1940 **625 .214**
Railway Mechanical Engineer, February, p. 69.
PEARCE (E. S.). — Distribution and sources of **journal box temperature** (Abstract of paper presented to the A. S. M. E.). (1 600 words & fig.)

1940 **625 .212 (.73) & 625 .26 (.73)**
Railway Mechanical Engineer, February, p. 70.
Improvements at the Readville shop (N.Y., N.H. & H.) facilitate **demounting wheels.** (1 300 words & fig.)

Railway Signaling. (Chicago.)

1940 **656 .254 (.73)**
Railway Signaling, February, p. 85.
Centralized traffic control on the New York, Ontario & Western (8.6 miles of single track between ends of double track, using **direct-wire system** with only 4 wires). (7 000 words & fig.)

1940 **625 .162 (.73) & 656 .259 (.73)**
Railway Signaling, February, p. 90.
7 automatic and automanual grade **crossing gates,** Alton RR. (7 000 words & fig.)

1940 **656 .256.3 (.73)**
Railway Signaling, February, p. 96.
Coded signaling control system on the Norfolk and Western. (7 700 words & fig.)

Transit Journal. (New-York.)

1940 **313 : 388 (.73)**
Transit Journal, January.
Annual statistics on City, suburban and interurban public transportation in North America. Etc. — 40 pag. (Price : $ 1.)

In Spanish.

Boletín de la Asociación internacional permanente del Congreso Sudamericano de ferrocarriles. (Buenos Aires.)

1939 **385**
Boletín de la Asoc. intern. perm. del Congreso Sudamericano de ferrocar., nov.-diciembre, p. 25.
PEREIRA DE CASTILHO (A.). — « La mort du rail? » (7 000 palabras.) (Continuará.)

1939 **385 (.42)**
Boletín de la Asoc. intern. perm. del Congreso Sudamericano de ferrocar., nov.-diciembre, p. 41.
SHERRINGTON (C. E. R.). — Los **ferrocarriles britanicos y la guerra.** (3 600 palabras.)

1939 **656 (.44)**
Boletín de la Asoc. intern. perm. del Congreso Sudamericano de ferrocar., nov.-diciembre, p. 50.
HARCAVI (G.). — El problema de la **coordinación de transportes** en Francia. (Continuación.) (3 000 palabras.) (Continuará.)

In Italian.

Annali dei lavori pubblici. (Roma.)

1940 **721 .1**
Annali dei lavori pubblici, gennaio, p. 35.
SALVATORE CANNAVO' di Paolo. — Breve esame critico dei sistemi e metodi di **fondazione in terreni cedevoli.** (6 000 parole & fig.)

L'Ingegnere. (Milano.)

1940 **624 .23**
L'Ingegnere, n° 2, 15 febbraio, p. 114.
SASSI (G.). — La realizzazione pratica degli elementi di isostaticità nelle strutture dei ponti quale fu ot nuta in Etiopia nei maggiori **ponti in cemento arma** Cap. II : Gli apparecchi di dilatazione. (4 000 parole fig.) (Continua.)

Rivista tecnica delle ferrovie italiane. (Roma.

1940 **621 .133.1 (.4**
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1940 385 (.3 + .4)

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 12, 20. März, S. 145; Nr. 13, 28. März, S. 161; Nr. 14, 4. April, S. 175; Nr. 15, 11. April, S. 191.

Rückblick auf das **Jahr 1939** (Fortsetzung und Schluss). (37 500 Wörter.)

1940 385. (07 (.43)

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 16, 18. April, S. 207.

BINDEMANN. — Das **Unterrichtswesen** der Deutschen Reichsbahn. (3 700 Wörter.)

1940 656 (.52)

Zeitung des Ver. mitteleurop. Eisenbahnverw., Nr. 16, 18. April, S. 211.

SIKAMA (Dr. K.). — Das japanische Verkehrssystem zu Lande. (2 800 Wörter.)

In English.

Bulletin, American Railway Engineering Association. (Chicago .)

1940 624. (.73)

Bulletin, American Railway Engineering Association, No. 415, January, p. 323.

Report of Committee 7. — **Wood bridges and trestles.** — Specifications for driving wood piles. Specifications and designs of fastenings for timber structures. Use of asphalt and tar compositions for wearing surfaces of wood bridges. Etc... (12 000 words & fig.)

1940 **693. (.73)**
Bulletin, American Railway Engineering Association, No. 415, January, p. 351.
Report of Committee 8. — Masonry. — Revision of manual. Specifications and principles of design of plain and reinforced concrete. Specifications for foundations. Lining and relining of tunnels. Cement manufacture and testing. Pressure grouting. Etc... (20 000 words & fig.)

1940 **624. (.73) & 721 .9 (.73)**
Bulletin, American Railway Engineering Association, No. 415, January, p. 407.
Report of Committee 15. — **Iron and steel structures.** — Progress in design of steel bridge details. (5 000 words & fig.)

1940 **657 (.73)**
Bulletin, American Railway Engineering Association, No. 415, January, p. 445.
Report of Committee 11. — **Records and accounts.** — Office and drafting practices. Maintenance of way statistics (forms). Construction reports and records. Bridge and building records. Valuation. (10 500 words & fig.)

Engineer. (London.)

1940 **623 (.42) & 625 .26 (.42)**
Engineer, March 29, p. 313.
Mobile railway workshops for Br. Ex. Force. (800 words & fig.)

1940 **621 .39 & 669**
Engineer, April 5, p. 323 and April 12, p. 394.
FLEMING (A. P. M.). — **Electricity as applied to metallurgy.** (6 800 words, tables & fig.)

1940 **621 .86 (.42) & 625 .26 (.42)**
Engineer, April 12, p. 350.
Carriage body lifting cranes, G. W. R. (650 words & fig.)

1940 **621 .132.8**
Engineer, April 19, p. 366 and April 26, p. 390.
LIVESAY (Edward H.). — Turbine locomotive experiences. (To be continued.) (6 200 words & fig.)

1940 **621 .18**
Engineer, April 19, p. 381 and April 26, p. 405.
POLLITT (A.). — Development in design of boilers and boiler house auxiliaries. (To be continued.) (8 200 words, 3 tables & fig.)

1940 **669 .1**
The Metallurgist, Supplement to « The Engineer », April 26.
Influence of rate of cooling on the transformations in chromium steels. (2 200 words & fig.)

Engineering. (London.)

1940 **624 .63 & 721 .4**
Engineering, March 29, p. 321.
CHERRE (V.). — **Movable centring for reinforced-concrete arches.** (2 500 words & fig.)

1940 **62 (01 & 669**
Engineering, March 29, p. 325.
ELAM (C. F.). — Non uniform **yielding in metals during a tensile test.** (3 300 words, table & fig.)

1940 **62 (01 &**
Engineering, March 29, p. 345.
WATTS (O. P.). — The **corrosion of metal.** — versity of Wisconsin, Engineering Experiment Sta Bulletin, No. 83. Abridged. (5 200 words.)

1940 **621 .5 (.42), 621 .86 (.42) & 651 (**
Engineering, April 12, p. 375.
Telegram-form conveying systems : General Office. I. (8 500 words & fig.)

Engineering News-Record. (New York.)

1940 **624 .1 (.**
Engineering News-Record, February 29, p. 36.
Long piles and floating caissons for Potomac R bridge piers. (3 000 words & fig.)

1940 **624 .1 (.73) & 624 .7 (.**
Engineering News-Record, February 29, p. 41.
DUNHAM (Clarence W.). — **Viaduct approach** Lincoln Tunnel (New York) (six-lane viaduct on meadows). (3 000 words & fig.)

1940 **691 &**
Engineering News-Record, March 7, p. 43.
Placing and weathering of concrete. — Discussi 36th Convention, American Concrete Institute, Chic (2 700 words.)

1940 **624 .62 (.**
Engineering News-Record, March 14, p. 48.
Tied arches to span the Mississippi at Rock Isla — Five 395 and 540-ft. spans. (3 500 words & fig.)

1940 **691 &**
Engineering News-Record, March 14, p. 67.
Progress in **concrete research** (Meeting, Amer. C crete Inst.). Ready mixed concrete. — Vibrated concr vs. tamped concrete. (3 800 words & fig.)

1940 **624 .2 (.**
Engineering News-Record, March 28, p. 60.
Pre-stressed 108-ft. girders in German bridge. words & fig.)

Journal of the Institution of Civil Engineers. (London.)

1940 **626 .13**
Journal, Institution of Civil Engineers, March, p.
BARNES (William). — The **dragline excavator.** per and discussion. (17 000 words, tables & fig.)

1940
Journal, Institution of Civil Engineers, April, p.
GARDNER (Alfred Charles). — The construction deep-water quays (Vernon-Harcourt lecture). (5 words & fig.)

1940 **62. (01, 624 .2 & 721**
Journal, Institution of Civil Engineers, April, p.
INGLIS (Prof. Charles Edward). — The crippl load of a compression member in a framework w stiff joints. (5 000 words & fig.)

940 625 .22 & 656 .281 (.54)
nal, Institution of Civil Engineers, April, p. 235.
ALBERG (Frank James). — Derailments of four-eled stock on the Northern section of the Assam-gal Railway. Experiments in the running and la-l oscillation of this four-wheeled stock. (1 100 words g.)

ournál, Institution of Engineers, Australia (Sydney).

940 624 .1 & 721 .1
rnal, Institution of Engineers (Australia), January, p. 21.
LYNN (D. E.). — A review of **soil mechanics** and application to civil engineering. (7 600 words &

Journal, Institute of Transport. (London.)

940 38. (.42) & 623. (.42)
rnal, Institute of Transport, No. 2, Jan., p. 43.
UAN WALLACE. — The functions of the **Ministry Transport in war-time.** (2 800 words.)

940 656 .24
rnal, Institute of Transport, No. 2, Jan., p. 46.
EAN (H. R.). — **Transport and insurance.** (8 500 ds.)

940 385 .517.7 (.68)
rnal, Institute of Transport, No. 2, Jan., p. 55.
OFFE (Ch. M.). — **Housing a staff of 120 000.** 00 words.)

940 656 .23 (0
rnal, Institute of Transport, March, p. 75.
AMPBELL (Dr. C. Douglas). — The empirical **fore-ting of railway traffic.** (6 500 words & fig.)

Journal and Proceedings, Institution of Mechanical Engineers. (London.)

940 621 .39 (.42) & 621 .436 (.42)
ceedings, Institution of Mechanical Engineers, April, p. 39.
MITH (F. D.), LAKEY (E. H.) and MORGAN). — The Admiralty **cathode-ray oscillograph engine icator.** (6 000 words & fig.)

940 621 .39 (.42) & 621 .436 (.42)
ceedings, Institution of Mechanical Engineers, April, p. 48.
MITH (F. D.). — Basic principles in the design of **hode-ray oscillograph engine indicators.** (7 000 words ig.)

940 62 (01 & 669
ceedings, Institution of Mechanical Engineers, April, p. 56.
MITH (F. D.) and LUXFORD (C. A.). — **Stress asurement** by magnetostriction. (1 700 words & fig.)

ırnal, Permanent Way Institution. (London.)

940 625 .123
rnal, Permanent Way Institution, vol. LVII, Part III, Dec., p. 279.
OWARD (R. E.). — **Permanent way drainage.** 500 words & fig.)

1940 625 .18 (.42)
Journal, Permanent Way Institution, vol. LVII, Part III, Dec., p. 295.
HICKMAN (P. R.). — **Supply of permanent way materials,** L. M. S. R. Railway. (4 600 words.)

1940 625 .14 (.91)
Journal, Permanent Way Institution, vol. LVII, Part III, Dec., p. 304.
CRUYKSHANK (J.). — Federated Malay States Railways **recent track developments.** (7 000 words & fig.)

1940 62 (01 & 624 .2
Journal, Permanent Way Institution, vol. LVII, Part III, Dec., p. 321.
RIGBY (W. L.). — **Impact on railway underbridges.** (4 800 words & figs.)

1940 625 .18 (.42)
Journal, Permanent Way Institution, vol. LVII, Part III, Dec., p. 335.
HUTT (E. T.). — From track to scrap heap. Some of the methods employed by the G. W. R. in **dealing with second-hand permanent way.** (7 500 words & fig.)

Locomotive, Railway Carriage & Wagon Review. (London.)

1940 625 .28 & 656 .21
The Locomotive, Ry. Carr. & Wag. Rev., March 15, p. 59.
Some **aspects of railway progress as they affect the Locomotive Department** (To be continued). (3 800 words & fig.)

1940 621 .431.72 (.45) & 621 .433 (.45)
The Locomotive, Ry. Carr. & Wag. Rev., March 15, p. 76.
A new **charcoal gas railcar,** Italian State Railways. (800 words & fig.)

1940 621 .13 (0 & 669 .1
The Locomotive, Ry. Carr. & Wag. Rev., March 15, p. 79.
Some **modern locomotive steels** (Firth Brown). (2 200 words & fig.)

1940 621 .132.8 (.73)
The Locomotive, Ry. Carr. & Wag. Rev., April 15, p. 86.
2-8-8-4 **articulated locomotives,** Southern Pacific Lines. (1 000 words & fig.)

1940 621 .132.3 (.493)
The Locomotive, Ry. Carr. & Wag. Rev., April 15, p. 89.
New « **Atlantic** » **type locomotives,** Belgian National Railways Company. (1 400 words & fig.)

1940 623. (.42) & 625 .26 (.42)
The Locomotive, Ry. Carr. & Wag. Rev., April 15, p. 91.
Mobile workshops for the British Expeditionary Force (Southern Ry.). (900 words & fig.)

1940 621 .132.3 (.460)
The Locomotive, Ry. Carr. & Wag. Rev., April 15, p. 92.
New 4-8-2 **streamlined steam locomotives,** Madrid, Saragossa & Alicante Ry. (350 words & fig.)

1940 **621 .335 (.42) & 621 .338 (.42)**
The Locomotive, Ry. Carr. & Wag. Rev., April 15, p. 95.
Electric motor coach trains. Brief abstracts from paper read by Mr. H. H. Andrews before the Inst. of Locom. Engrs, 13-3-40. (2 400 words.)

1940 **621 .132.8 (.44) & 621 .133 (.44)**
The Locomotive, Ry. Carr. & Wag. Rev., April 15, p. 102.
« **Velox** » **steam generator** fitted on P. L. M. compound express engine. Particulars of locomotive as running. (2 000 words & fig.)

1940 **625 .235**
The Locomotive, Ry. Carr. & Wag. Rev., April 15, p. 110.
Carriage painting. Synthetic finishes on railways abroad. (1 000 words.)

Mechanical Engineering. (New York.)

1940 **62 (01 & 625 .213**
Mechanical Engineering, April 1940, p. 289.
TATNALL (Rodman R.). — Factors in the **fatigue of helical springs.** (3 200 words & fig.)

1940 **669 .1**
Mechanical Engineering, April 1940, p. 293.
VILELLA (J. R.). — The **grain size of steel.** An introduction to the subject. (1 200 words & fig.)

1940 **62 (01**
Mechanical Engineering, April 1940, p. 311.
LESSELLS (John M.). — **Significance of tension test.** Background of a proposed symposium to discuss relation of tensile test of metals to design. (4 400 words & fig.)

Modern Transport. (London.)

1940 **621 .335 (.42) & 621 .338 (.42)**
Modern Transport, March 23, p. 3.
ANDREWS (H. H.). — **Equipment of electric motor coach trains.** — No. 2. Position of control gear : Choice of electrical systems. (From a paper read before the Instit. of Locomotive Engineers, London, March 13.) (4 800 words & fig.)

1940 **385 (091 (.47) & 656 .2 (.47)**
Modern Transport, March 23, p. 7.
Transport in Soviet Russia. Characteristics of railway system. (3 800 words & tables.) (To be continued.)

1940 **623 (.42) & 625 .26 (.42)**
Modern Transport, March 30, p. 3.
Mobile railway workshop for British Expeditionary Force. Ministry of Supply unit completed by Southern Railway. (1 200 words & fig.)

1940 **623 (.42) & 656 .226.6 (.42)**
Modern Transport, April 6, p. 3.
Freight train working in wartime. Ensuring « next-morning » deliveries. L. M. S. operating methods. (2 700 words, table & fig.)

1940 **623 (.494) & 656 .2 (.494)**
Modern Transport, April 6, p. 10.
Wartime operation of Swiss Railways. (1 600 words & fig.)

1940 **621 .33 (.42) & 625 .42 (**
Modern Transport, April 13, p. 3; April 20, p. 7.
Tube train service to High Barnet. Rapid Transi
L. N. E. R. branch and resignalling. Direct railway
with West End. (1 800 words & fig.)

1940 **629 .113.62 (**
Modern Transport, April 13, p. 5.
Outrigger construction for trolleybuses. Alterna
to chassisless vehicles. Interesting A. E. C. deve
ments. (1 000 words & fig.)

1940 **385 (091 (.**
Modern Transport, April 13, p. 11.
Railway communications in Norway. Principal
tures of Government System. Ore traffic on Na
line. (1 700 words & fig.)

1940 **621 .13 (0 (.**
Modern Transport, April 20, p. 2.
Locomotive design in France (Comments on p
read by M. Chan before Inst. of Locomotive Engine
(1 000 words.)

1940 **385. (091 (.4**
Modern Transport, April 20, p. 3.
Railways and Ports in Rumania. Main routes
principal traffics. Importance of oil exports. (2
words & fig.)

1940 **625 .42 (.42) & 656 .25 (.**
Modern Transport, April 20, p. 3.
Tube train service to High Barnet. No. 2. Resignal
L. N. E. R. branch (900 words & fig.)

Oil Engine. (London.)

1940 **621 .431.72 (.**
Oil Engine, April, p. 358.
High-power shunting locomotives. 28 standard die
electric units with engines of 1 000 B. H. P. and
B. H. P. (Baldwin). (1 200 words.)

1940 **621 .**
Oil Engine, April, p. 372.
Latest Ganz-Jendrassik **traction engine.** 12 and
cylinder V-type. (900 words & fig.)

Proceedings, American Society of Civil Engineers. (New York.)

1940 **624 .1 (.73) & 627 .82 (.**
Proc., Amer. Soc. Civ. Eng., March, p. 383.
Foundation experiences, Tennessee Valley Author
A symposium : 5 papers by James S. LEWIS Jr.,
bert M. ROSS, Verne GONGWER, Portland P. F
and James B. HAYS. (50 000 words, tables & fig.)

Railway Age. (New York.)

1940 **621 .431.72 (.73) & 625 .26 (.**
Railway Age, March 2, p. 397.
Pioneer Zephyr (Chicago Burlington and Quincy)
repaired in record time after serious collision. (3
words & fig.)

940 **656 .213 (.73)**
Railway Age, March 2, p. 401.
Union Pacific gives Denver **modern produce terminal.** (1 words & fig.)

940 **625 .162 (.73) & 656 .259 (.73)**
Railway Age, March 2, p. 410.
Short-arm gates with signals at seven Alton cross- (2 700 words & fig.)

940 **625 .162 (.73)**
Railway Age, March 9, p. 433.
Federal grade-crossing elimination program shows ened pace. (5 000 words & fig.)

940 **621 .335 (.81)**
Railway Age, March 9, p. 438.
Electric locomotives (2 C + C 2) for the Paulista Way. (2 500 words.)

940 **621 .431.72 (.73)**
Railway Age, March 9, p. 446.
Timiskaining & Northern Ontario **diesel-powered train (converted from gasoline railcar).** (1 900 ds & fig.)

940 **625 .245 (.73) & 625 .246 (.73)**
Railway Age, March 23, p. 542.
Light-weight riveted hopper cars for the Northern ific (ratio of pay load to tare = 3.12 to 1). (1 400 ds & fig.)

940 **624 .1 (.71)**
Railway Age, March 23, p. 544.
Bridge piers of structural steel piles meet with fa- on the Canadian National Rys. (5 000 words g.)

940 **625 .243 (.73)**
Railway Age, March 16, p. 489.
Delaware, Lackawanna & Western **light-weight box** A. A. R. 50-ton cars embodying the use of U S S Ten steel, weigh 44 000 lb. (1 600 words & fig.)

940 **625 .1 (06 (.73)**
Railway Age, March 16, p. 498.
Engineering and Maintenance Officers meet at Chi- 12-14 March. (Abstracts of the principal addresses reports). (40 000 words & fig.)

940 **656 .213 (.73) & 725 .32 (.73)**
Railway Age, March 30, p. 584.
Five Roads join in building **modern produce facilities.** **Modern terminal** with up to date layout und equip- at Denver, Colo. (4 300 words & fig.)

940 **621 .431.72 (.494) & 621 .437 (.494)**
Railway Age, March 30, p. 588.
Combustion turbine as prime mover for locomotives. Proposal combining the turbine with hydraulic trans- sion and worm-gear drive, all developed in other ds. (4 000 words & fig.)

940 **625 .216**
Railway Age, April 6, p. 619.
Draft gears. — Their relation to riding comfort of — Data obtained from passenger-train tests. 00 words & graphs.)

1940 **621 .138.2 (.73)**
Railway Age, April 6, p. 624.
New coal dumper on the Pennsylvania handles a car a minute. (4 300 words & fig.)

1940 **625 .245 (.73)**
Railway Age, April 6, p. 636.
Lightweight hopper cars for the Delaware, Lackawanner & Western. (700 words & fig.)

Railway Engineering and Maintenance. (Chicago.)

1940 **625 .144.4 (.73)**
Railway Engineering and Maintenance, March, pp. 154 to 171.
Work equipment (A series of 4 articles on). — On — and off — track equipment. (17 000 words & fig.)

1940 **625 .144.4 (.73) & 625 .19 (.73)**
Railway Engineering and Maintenance, March, p. 172.
New Haven **centralizes the repair of its work equipment.** (5 600 words & fig.)

Railway Gazette. (London.)

1940 **625 .26 (.42) & 725 .33 (.42)**
Railway Gazette, March 15, p. 377.
Carriage & Wagon Department developments, G. W. R. — **High-capacity storage shed** at Swindon and new **carriage lifting and painting shops** at Caerphilly. (1 100 words & fig.)

1940 **623 & 656**
Railway Gazette, No. 29, March 15, p. 386, No. 30, March 22, p. 422, No. 31, March 29, p. 470, No. 32, April 5, p. 518; No. 33, April 12, p. 550.
Transport services and the war. (23 000 words & fig.)

1940 **656 .222.1 (.493)**
Railway Gazette, March 15, p. 390.
High-speed locomotive work in Belgium (New **Atlantics** and Standard **Pacifics** on the Brussels-Ostend line). (3 000 words & fig.)

1940 **621 .135.5 & 625 .253 (.42)**
Railway Gazette, March 22, p. 407.
Westinghouse brake on British engines in France. Application of air-operated graduable steam brake to Westinghouse-fitted locomotive. (1 000 words & fig.)

1940 **621 .132.5 (.931)**
Railway Gazette, March 22, p. 410.
New light **4-8-2 locomotives** for working mixed traffic on 50-lb. per yard rail in New Zealand. (1 900 words & fig.)

1940 **62 (01 (.42) & 621 .135.2 (.42)**
Railway Gazette, March 29, p. 459.
Tyre failure investigations on the L. M. S. R. — Analysis of a typical example in a 0-6-0 locomotive. (1 200 words & fig.)

1940 **625 .11 (.492) & 725 .31 (.492)**
Railway Gazette, March 29, p. 460.
New **works** at Amsterdam. Important improvements including **elimination of level crossings** and provision of two **new stations.** (1 500 words & fig.)

1940 **623 (.42) & 625 .26 (.42)**
Railway Gazette, March 29, p. 463.
The first **mobile railway workshop train** (for B. E. F.). (1 300 words & fig.)

1940 **621 .138 (.493)**
Railway Gazette, April 5, p. 499.
CHANTRELL (A.). — **Locomotive maintenance,** Belgian National Railways. Reduction in man-hours and time of withdrawal from service achieved by reorganisation of workshops and systematic schedule of operations. (2 300 words.)

1940 **656 .1 (.492) & 656 .261 (.492)**
Railway Gazette, April 5, p. 506.
Dutch rail and road goods services. — Co-operation with a general transport concern and local carriers is working successfully. (550 words.)

1940 **623 (.42) & 656 .1 (.42)**
Railway Gazette, April 5, 511.
Road transport and the War. — 7. (2 400 words & fig.)

1940 **621 .132.8 (.73)**
Railway Gazette, April 12, p. 540.
Articulated 2-8-8-4 mixed-traffic locomotives for 75 m. p. h., Southern Pacific (Lima). (2 000 words & fig.)

1940 **625 .111 (.494) & 656 .25 (.494)**
Railway Gazette, April 12, p. 542.
Improved **approach to Lucerne.** (Widened approaches, colour-light signals, long-distance point operation). (1 700 words & fig.)

1940 **656 .211.5 (.493)**
Railway Gazette, April 19, p. 568.
New standard station shelters, Belgian National Rys. Co. (250 words & fig.)

1940 **385. (01 (.71)**
Railway Gazette, April 19, p. 570.
Canadian Pacific railway land grants. (1 200 words.)

1940 **385. (091 (.481 + .485)**
Railway Gazette, April 19, p. 571.
The Lapland iron ore railway (Lulea-Narvik). (4 000 words & fig.)

1940 **621 .132.8 (.494)**
Railway Gazette, April 26, p. 604.
One-man steam locomotive operation, Langenthal-Hantwil Railway, Switzerland. (700 words & fig.)

1940 **625 .244 (.71)**
Railway Gazette, April 26, p. 607.
New refrigerator cars, Canadian National Rys. (Overhead-iced cars, which can also be charcoal-heated). (700 words & fig.)

1940 **621 .13 (0 (.44)**
Railway Gazette, April 26, p. 618.
Locomotive developments in France (Abstract of paper by M. Chan, presented before the Institution of Locomotive Engineers, April 17). (4 100 words.)

1940 **621 .431.72 (.73)**
Diesel Railway Traction, p. 32, Supplement to the Railway Gazette, March 15.
High-power main-line diesel-electric locomotives in the U. S. A. (description of seven 2 000-B. H. P. units — Electro-Motive Corporation — for express haulage on the Burlington Lines). (3 400 words & fig.)

1940 **621 .431.72 (.**
Diesel Railway Traction, p. 35, Supplement to the R way Gazette, March 15.
French 635-H. P. **diesel-electric shunting locomot** (hauling 700 tons up 1 in 72 gradients at 4 1/2 m.p (1 000 words & fig.)

1940 **621 .431.72 (.9**
Diesel Railway Traction, p. 37. Supplement to the R way Gazette, March 15.
English-built **railcar** for Tasmania — 153-B. H. Gardner engine. For Specialized traffic on 3 ft. 6 line. (2 500 words & fig.)

1940 **621 .431.72 (.4**
Diesel Railway Traction, p. 40. Supplement to the R way Gazette, March 15.
Diesel traction in Denmark. Progress during the p 15 years. (Paper presented by P. Knutzen, Gen Manager, State Rys., to Danish Inst. of Enginee (2 000 words & fig.)

1940 **621 .331 (.**
Electric Railway Traction, p. 40, Supplement to Railway Gazette, April 26.
READ (J. C.). — Rectifier equipment for rege rative working. — Requirements, design and operat of the B. T.-H. rectifier-inverter plants of the Durb Volksrust section of the South African Railways. (7 words & fig.)

1940 **621 .431.72 (.**
Diesel Railway Traction, p. 44, Supplement to the R way Gazette, April 12.
A dozen new **diesel-mechanical railcars** for Buenos Ayres & Pacific Railway (broad-gauge pass ger and parcels traffic). (2 600 words & fig.)

1940 **621 .431.72 (.7**
Diesel Railway Traction, p. 48, Supplement to the R way Gazette, April 12.
Mixed-traffic diesel-electric locomotives for U. S. Mexican frontier line. (600 words & fig.)

1940
Diesel Railway Traction, p. 49, Supplement to the R way Gazette, April 12.
Methane as an engine fuel. (1 100 words.)

1940 **621 .431.72 (.**
Diesel Railway Traction, p. 50, Supplement to the R way Gazette, April 12.
Diesel-electric locomotive for heavy grades (M gauge, Madagascar). (600 words.)

1940 **621 .431.72 (.4**
Diesel Railway Traction, p. 51, Supplement to the R way Gazette, April 12.
Spanish railcar progress. — Services, costs, fina and future plans. (1 100 words.)

1940 **623 (.489) & 621 .431.72 (.4**
Diesel Railway Traction, p. 51, Supplement to the R way Gazette, April 12.
Wartime diesel traffic in Denmark. (1 500 word map.)

40 **621 .33 (.73)**
ric Railway Traction, p. 32, Supplement to the Railway Gazette, March 29.
e Pennsylvania Railroad **electrification.** (2 200 s, maps & fig.)

40 **621 .335 & 621 .338**
ric Railway Traction, p. 35, Supplement to the Railway Gazette, March 29.
ltiple-unit electric trains. Abstract of paper read r. H. H. Andrews, before Institution of Locomotive neers, March 13. (3 000 words & table.)

Railway Magazine. (London.)

40 **656 .254**
vay Magazine, April, p. 193.
)CK (O. S.). — **Automatic train control.** (3 500 s & fig.)

40 **385 (09 (.438)**
vay Magazine, April, p. 228.
E (Charles E.). — **Poland and its railways.** II. (2 600 words & fig.)

ilway Mechanical Engineer. (New York.)

40 **621 .431.72 (.73) & 669**
vay Mechanical Engineer, March, p. 87.
uminium alloys feature construction of Missouri-ic Eagle trains (six-car de luxe trains of 596 980 hauled by 2 000 H. P. diesel locomotive). (5 300 s & fig.)

40 **625 .2 (01 & 625 .216**
vay Mechanical Engineer, March, p. 94.
e relation between draft gears and riding comfort. ts by the Waugh Equipment Company.) (3 400 s & fig.)

40 **621 .133**
vay Mechanical Engineer, March, p. 100.
RANDT (C. A.). — **A study of the locomotive r.** Effect of the absorption efficiency, grate area, -end design, superheater and feed-water heating he efficiency and capacity of the boiler. (5 000 s, tables & fig.)

40 **62 (01 (.73), 625 .235 (.73) & 656 .283 (.73)**
vay Mechanical Engineer, March, p. 107.
reau of Safety reports Pioneer Zephyr **wreck. age to stainless-steel train, which collided** with ding locomotive at high speed, confined largely to unit. — Little damage to locomotive. (1 800 s.)

Railway Signaling. (Chicago).

40 **656 .257 (.73)**
vay Signaling, March, p. 143.
terlockings installed at 2 railway crossings. Nu-us train stops eliminated by installing **table in-ckers** (Great Trunk Western crossing Belt Ry. & ash). (3 400 words & fig.)

40 **625 .162 (.73) & 656 .259 (.73)**
vay Signaling, March, p. 146.
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